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ABSTRACT

Because of a consistently high failure rate of freshmen in a required introductory biology course, numerous strategies to improve the success rate of students without compromising academic standards were explored. The major underlying cause of lack of success was perceived to be the level of thinking skills possessed by the incoming freshman. The level of thought, concrete, transitional or formal, was highly correlated to the degree of success for each student. It was proposed to develop curriculum materials based on the learning cycle instructional strategy that is founded on Piagetian learning theory. Laboratory experiences were rewritten to provide concept exploration and lecture materials were developed for concept introduction. The course was restructured so that exposure to concrete experiences in the laboratory leading to concept formation occurred first and verbalization of the formal concept followed through the formal lecture and discussion. Involvement with the restructured program increased the success rate, resulted in reduced dropouts and increased the overall morale and self-image of the students. This document contains project overviews, background, a project description, and results. Appendices, which make up the bulk of the document, include: (1) background information for Foundations In Problem Solving Education (FIPSE); (2) an example of FIPSE materials for the biology course; (3) a sample lecture outline; (4) a reprint of a journal article discussing the project; and (5) project evaluation and experimental data. (CW)

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ED299120

RESTRUCTURING INTRODUCTORY BIOLOGY ACCORDING TO THE LEARNING CYCLE INSTRUCTIONAL STRATEGY

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SUMMARIES

RESTRUCTURING INTRODUCTORY BIOLOGY ACCORDING TO THE LEARNING CYCLE INSTRUCTIONAL STRATEGY

1. PARAGRAPH SUMMARY

Unique Piagetian learning theory-based curriculum materials for introductory college biology were developed that provide equal opportunity of success for students at concrete and transitional levels of thought as well as those at the formal level. Integrated laboratory-lecture life science units were designed according to the learning cycle format, utilizing the advantages of exposing students to concrete experiences in the laboratory that lead to the development of formal concepts through lecture and discussion. Use of the materials led to reduced failure rate, increase rather than decrease in enrollment in first two weeks, and significant positive changes in the affective domain.

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Products:

1. Biological Investigations for Foundations In Problem Solving Education (BIO-FIPSE is a laboratory manual for introductory biology)

2. Lecture Outlines for Concept Formation in the Life Sciences (A presentation guide in a lecture format for concept introduction)

2. EXECUTIVE SUMMARY

RESTRUCTURING INTRODUCTORY BIOLOGY ACCORDING TO THE LEARNING CYCLE INSTRUCTIONAL STRATEGY

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A. Project Overview

Because of a consistently high failure rate of freshmen in the required Introductory Biology 10 Course, the faculty of the Department of Biology at the University of Missouri-St. Louis explored numerous strategies to improve the sucess rate of students without compromising academic standards. After attempting several mechanical and administrative adjustments that did not help, it was proposed to develop curriculum materials based on the learning cycle instructional strategy that is founded on Piagetian learning theory. Laboratory experiences were rewritten to provide concept exploration and lecture materials were developed for concept introduction. The course was restructured so that exposure to concrete experiences in the laboratory leading to concept formation occurred first and verbalization of the formal concept followed through the formal lecture and discussion.

Over 100 beginning biology major students were introduced to the uniquely developed materials. Twelve percent of the class were minority students, a group of which nearly all historically fell into the unsuccessful category. Involvement with the restructured program reduced the unsuccessful rate, resulted in reduced dropouts and increased the overall morale and self-image of the students.

B. Purpose:

The purpose of this project was to reduce the number of unsuccessful students that enrolled in the Introductory Biology 10 and therefore increased the number of students that had an opportunity to major in biology or prepare for careers in the life sciences or allied health fields. Prior to the restructuring of the introductory course through this project, nearly half of all students either dropped the course or received terminal grades of F or D. This problem occurs with greater or lesser severity in most institutions of higher learning that are attempting to maintain quality academic standards.

The major underlying cause of this problem was perceived to be the level of thinking skills possessed by the incoming freshman. The level of thought, concrete, transitional or formal, was highly correlated to the degree of success for each student. This project addressed the problem of failure by developing curriculum materials in the life sciences that assumed concrete mental operational skills and that lead students through formal reasoning patterns to concept formation.

C. Background and Origins

The University of Missouri-St. Louis is an urban institution that serves the greater metropolitan St. Louis area and enrolls approximately 11,000 students.

Entrance ACT scores of the students are at that national average for public institutions. In addition, approximately 50% of the students enrolling in the Introductory Biology course are at the concrete level of thought, about the same level as national studies indicate for other schools. Problems of dropout and failure in introductory courses are common in science disciplines in higher education.

A history of unsuccessful attempts to alter subject matter content, administrative procedures, textural materials, etc. caused increased concern and anxiety within the members of the Department of Biology. Considerable changes in attitude and perspective among faculty members had to take place before a project that focused on pedagogy, and specifically learning theory, could be undertaken to help remedy the situation.

Prior to funding by FIPSE, there was very little support from the administration at any level. However, after the project was initiated, considerable financial and personnel support came from the Department and the Office of the Dean.

D. Project Description

The major feature of the project was to prepare curriculum materials that would give students at either the concrete or formal levels of thought equal opportunity to master basic concepts in the biological sciences. This was accomplished by writing laboratory experiences that incorporated the learning cycle teaching strategy as derived from Piagetian learning theory. Twelve major laboratory experiences were written and tested that included exploration, concept formation and concept application. In addition, lecture outlines that were designed to formalize the concepts were prepared. Lectures and laboratories were closely integrated and the traditional lecture relating ---> laboratory confirmation sequence was reversed to laboratory experience and then lecture confirmation.

The materials were developed based on our specific student needs, faculty skills, equipment inventory and current physical facilities. Three faculty members, two outside consultants, three graduate students, one undergraduate student and members of the preparation's office were involved in the development and testing of the materials. In addition, the equivalence of a quarter-time secretary was needed for clerical duties.

The project was originally scheduled to be completed within one year but an additional year was needed to rewrite and re-test outcomes. The project is still ongoing with a fourth rewrite currently underway.

Total cost of the project was nearly $150,000 of which FIPSE sponsored $81,549. The project could be accomplished with less personnel cost if teaching loads could have been reallocated within the department.

E. Project Results

The most surprising aspect of the results of the project was the increased positive attitude of students experiencing the new materials. They expressed excitement, increased curiosity and had a better understanding of their accomplishments. They seemed to place more value on their work and could see a direct connection between time on task and their mental development.

The results of the project have been presented locally through a Biology Teachers Association (NABT Affiliate) workshop; state wide by a presentation at the Missouri Academy of Science Science Education section; nationally as a sponsored workshop at the Association for Biology Laboratory Education and through a National Science Teachers Association's presentation. In addition, a local school district has asked for a presentation on the project to its secondary science teachers.

The project resulted in the development of two sets of instructional materials. A laboratory manual consisting of 12 experiences averaging 22 pages each was written and entitled Biological Investigations for Foundations in Problem Solving Education (BIO-FIPSE). The second set of materials were Lecture Outlines for Concept Formation in the Life Sciences. The outlines furnish a guide to lecture format presentations that lead to concept formation. The outlines parallel the laboratory experiences in subject matter and are designed to follow the concept introduction activities in the respective laboratory. Copies of the course materials can be obtained by writing to the project director and enclosing a duplication and mailing charge of $28.00 payable to the University of Missouri. Members of the project team are most willing to exchange information and ideas with those individuals with similar concerns or interests.

F. Summary and Conclusions

Although the project has been completed in a formal sense, it is obvious that modification and testing will continue indefinitely. The faculty have been caught up in the spirit of science education and are supporting true introspection and research into the effectiveness of educational practices. This is a most rewarding behaviorial change aside from the positive affect on the affective domain of the students.

We feel that we are definitely on the right tract but have come to the realization that more individualization will be needed to be comprehensive in our effort to meet student needs. It appears that the generation of curriculum materials that will meet a wide variety of institutions and student needs is impossible and that self-generated, specific materials will eventually be found to be the most effective.

BODY OF REPORT

RESTRUCTURING INTRODUCTORY BIOLOGY ACCORDING TO THE LEARNING CYCLE INSTRUCTIONAL STRATEGY

PROJECT OVERVIEW

Students entering the University of Missouri-St. Louis vary greatly in their academic backgrounds. Such urban universities face a critical challenge in providing programs of academic excellence which attempt to meet the needs of students at opposite ends of the college preparatory spectrum. Restructuring Introductory Biology According to the Learning Cycle Instructional Strategy was a two year curriculum development program that addressed the diversity of preparation problem for the instructors of Introductory Biology (Biology 10) and for approximately 100 freshman students who elect to major in biology annually and must, therefore, successfully complete the Introductory Biology course.

Over the past ten years, grade distributions in Biology 10 have consistently been bimodal, with as many as 45% of the students in the "unsuccessful" group. Moreover, over a five year period, 75% of the ethnic minorities fail to complete the course satisfactorily and not one of the 20 such students enrolled in the two semesters prior to this project obtained a "successful" grade (A, B or C).

The purpose of the "Restructuring Introductory Biology" project was to revise the introductory biology course material so that it would be based on Piagetian learning theory and incorporate the three phases of the learning cycle teaching strategy: (1) Exploration; (2) Concept Formation; and (3) Concept Application. The goal was to develop student skills in synthesizing concrete knowledge into formal concepts and, subsequently, foster the utilization of these concepts in solving related problems.

The approach structured the concepts presented so that they were chronologically congruent with the natural and historical discovery of scientific concepts and within subject areas start the conceptual development utilizing concrete or experiential encounters. The lectures incorporated three dimensional and two dimensional class inclusive examples. The teachers developed presentations that modeled concept formation and a series of related problems were presented with teacher/class cooperative solutions developed to provide the application phase. One hour discussion sessions allowed assessment and broadening of the understanding of concepts derived in lectures. Utilizing the three phases of the learning cycle, laboratory experiences were designed to lead students in the production of data that was to be used in concept development and application.

By the implementation of the learning cycle strategy the unsuccessful rate in the introductory course was reduced and an actual increase in student numbers was witnessed throughout the trial semester.

PURPOSE

Past experience in teaching the introductory biology course at the University of Missouri-St. Louis has been frustrating. Over the years, student performances in this course invariably have followed a bimodal distribution. One mode is in the moderate to high achievement category; the other is in the failing and unsatisfactory range. Furthermore, the latter mode has contained a disturbingly large number of students, averaging 40-55% of the total enrollemnt in the course.

The situation had special meaning since an extremely high percentage of the enrolled minority students were unsuccessful in the course. Ten percent of the students enrolled in the Winter 1983 and Fall 1983 semesters were minority students. Fifty percent of these minority students withdrew from the class before mid-term and the remainder failed the course. Although admission records indicate that some of these minority students may have deficient academic backgrounds, the records also indicate that they have the same innate potential to make significant contributions in the areas of science and technology and to the community at large as the general student body.

The failure on our part to serve these students effectively results in loss of interest in pursuing careers in science and compounds the personnel shortages in technical areas. The University has the responsibilities to provide capable students with the opportunity to complete the biology program and to prepare them adequately for careers in science.

The basic problem was the mismatch between the functional level of students entering the introductory course in biology for majors and the curriculum and academic expectations in the course.

The main objective of this project was to develop a means of instruction which would help eliminate the bimodal distribution of achievement in the introductory course for biology majors by reducing the student failure rate without jeopardizing the quality of the program. Since the basis for the dichotomy in achievement appeared to stem from the lack of formal reasoning skills, we restructured the lecture, discussion, and laboratory components of the course to assist in the development of formal reasoning patterns.

BACKGROUND AND ORIGINS

The University of Missouri-St. Louis was established in 1963 as the fourth campus of the University of Missouri System and is the only state-supported four-year university in the St. Louis metropolitan area. It has no resident housing, and 98 percent of its students commute from within 30 miles of the campus. The University is a major urban institution whose mission is to provide access to state-supported higher education for over 11,000 students with widely diverse cultural and educational backgrounds. The inconsistency in the pre-college preparation of students presents the faculty with a difficult challenge in their efforts to maintain a program of academic excellence while trying to meet the broad spectrum of student needs, develop a learning environment that will enrich the lives of all students, and provide the basic skills necessary for successful careers.

This project was concerned particularly with the entry level of students intending to major in biology. Currently these students are required to complete the Introductory Biology course (Biology 10) at a satisfactory level before they can enroll in more advanced courses in the program. Over 100 students a year enroll in Biology 10, and it is the basic course for the more than 350 students in the College of Arts and Sciences who have declared biology as a major.

Introductory Biology is a five credit, one-semester course which covers the general principles and major concepts of biology and also introduces the student to experimental design, problem-solving, data analysis and the nature of science. The analysis of test items and the nature of laboratory activities indicates that formal reasoning is required to meet approximately 80 percent of the objectives of the course. Incorporating formal reasoning process to this extent in the

introductory course has strengthened the overall program by providing a framework for the organization of biological information and necessary experience with scientific thinking and the scientific method. The students that do well in the introductory course continue to do well throughout the program, and they have been very successful in pursuing biology teaching, research, medical and other professional careers. However, the poor performance and consequent attrition of the large number of students at the lower end of the spectrum was of major concern.

Recent testing of the biology majors in the introductory course at the University of Missouri-St. Louis found that 72% of the students could not demonstrate formal proportional reasoning patterns given simple pencil and paper tests relating to manipulation of ratios. These preliminary findings parallel those found by other investigators at other schools when they tested college freshmen and found that only 25% demonstrated formal reasoning patterns. Without proportional reasoning, these students would not have the ability to conceptualize such basic concepts as cellular volume to surface area ratios, the Lincoln-Peterson index, quantitative microscopic examination, Hardy-Weinberg Law, structural ratios in speciation, certain aspects of Mendelian genetics, simple statistical tests, some homeostatic feedback systems, and quantitative osmotic phenomena.

On a student for student basis the performance records of the Introductory Biology students were highly correlated with their abilities to reason formally, as measured by the proportion puzzles. The problem centered around developing formal reasoning patterns in beginning college students so that the internalization of fundamental concepts in biology would transcend rote memory and build cognitive structures which would allow application and higher forms of problem solving. The ability to think formally about the concepts and principles of biology is critical to the understanding of the subject matter at the college level and broadens appreciation for the field of science and its processes. The project focused on the development of these skills in order to help those students who suffer from deficient backgrounds to complete the course successfully.

In order to increase the student success rate, we have, over a number of years, attempted to understand and resolve the differences between course expectations and student performance. The overriding problems have been the obvious bimodal distribution of student performance and the overwhelming failure rate of minority students. To address these problems, we have instituted several modifications.

1. Lowering of Textbook Reading Level (1975-78)
2. Heterogeneous Grouping of Laboratory Students with Good, Average and Poor Academic Backgrounds (1976)
3. Addition of Discussion/Study Sections (1979-present)
4. Broadened Prerequisites to Include Basic Mathematics and Writing Skills (1979-present)
5. Increased Exercises on Data Analysis and Scientific Process (1980-present)
6. Reduction of Student/Teacher Ratio in the Laboratory from 24 to 20 students per Section (1982-present)
7. Adoption of Commercial Problem Solving Oriented Laboratory Manual (1982-1984)

None of the results of the seven major attempts resolved the problem of failure rate. This led us to believe that a more systematic and philosophically rooted approach was essential and, therefore, the incorporation of the Piagetian base learning cycle instructional strategy was adopted as the pedagogical approach for this project. The continuing and increasing problems with the course helped convince a subject matter oriented faculty that a major change in philosophical approach was necessary. Upon receipt of the original proposal the faculty immediately provided cooperation and the Dean's Office provided financial and personnel support.

PROJECT DESCRIPTION

We felt that the crux of the problem resided in the mismatch between the functional level of the students in the group of concern and the curriculum as encountered in the classroom. In order to overcome the problem and reach our objectives we completely restructured the introductory biology course to incorporate the learning cycle as originated by J. M. Atkin and R. Karplus, based on Jean Piaget's learning theory. The laboratory, lecture and discussion activities were completely rewritten to include the three phases needed when applying Piagetian developmental theory to the advancement of student reasoning skills: (1) Exploration, (2) Concept Introduction, and (3) Concept Application. During the exploration phase, students work with concrete materials - observing, questioning and identifying problems that could not be explained by their current understanding. The second phase, concept introduction, is initiated when a concept or reasoning pattern is presented to the student or invented by the student and then is used by the student to increase understanding of the exploratory experience. The student's ability to apply the concept is extended during the concept application phase, which provides time and experiences for stabilization of the idea or reasoning process. Karplus called these three instructional phases the learning cycle strategy.

In addition, the traditional presentation sequence of lecture, discussion, and then laboratory was changed so that the laboratory hands-on experience for a given concept occured first, followed by the lecture and discussion.

Traditional Sequence:

Autocratic Lecture	-----> Clarification Discussion	-----> Confirmation Laboratory

FIPSE Project Sequence:

Experiential Laboratory	-----> Concept Lecture	Confirmation	-----> Application Discussion

The restructuring of the laboratory experiences was the most involved and time-comsuming component. Twelve 3 1/2 hour laboratory experiences were designed to (a) maximize the exploratory phase and provide alternative methods for concept formation for those students having difficulty utilizing formal reasoning patterns; (b) develop student awareness of reasoning processes; (c) provide concrete examples of biological principles; (d) guide students through thought processes leading to formal understanding of the major concepts in the biological sciences; and (e) coincide with the subject matter content of the lecture. In addition to the design and writing of laboratory experiences, appropriate models and other three dimensional examples were built or purchased. Appendix B

contains a copy of the table of contents for the collection of laboratory explorations entitled Biological Investigation for Foundations In Problem Solving Education (BIO-FIPSE). Also the first exploration, "Digestive System Structure and Function" is included to illustrate the general format and the nature of the activities.

Utilization of the lecture instructional strategy was congruous with the learning cycle approach only in its use to formally introduce the concept under consideration (Concept Formation). Some lecture outlines were restructured to incorporate a group exploration, teacher modeled concept formation, and a student self-testing concept application phase.

In order to accomplish this, the following steps were taken.

1. The subject matter sequence of the course was reordered to take into account the natural chronological flow of discovery and build from the simpler and more observable to the formal, more abstract.

2. Within each unit of subject matter, the concrete concepts were identified, and presented first. Formal aspects of the concepts were developed gradually.

3. Many illustrative physical examples, models and/or audio-visuals for each concept were developed to provide the needed concrete experience.

4. Each topic was introduced with a physically or two-dimensionally presented discrepant event or series of items which establish the properties of a set, using non-member items for contrast.

5. The textbook which was selected was Biology by Raven and Johnson (Times Mirror Mosby) and fits the need for concrete examples and experiences before developing formal concepts. A reading level of grade 11 was established for the text as measured by the Dale Long Readability Index. In addition, the sequence of reading topics was scheduled to be consistent with step 1.

6. Examinations were carefully developed so that they required formal reasoning processes only in areas where teaching strategies for developing formal reasoning patterns were used.

Although not a complete narrative, the lecture materials were written as a comprehensive outline to provide a highly structured guide for class presentations. Appendix C contains a sample outline on the topic of the Circulatory System.

The one hour per week discussion sessions were modified from the typical oral quiz/discussion format to one which:

1. Assessed the general understanding of the concepts presented in the three previous lecture sessions as specified in the application phase of the learning cycle.
2. Provided additional exploration and interactions with variables associated with concept development.
3. Incorporated the presentation of the more difficult concepts given in lecture from a different formal perspective using additional and more diverse examples.

Basically the discussion component was restructured from oral quizzing to one that tried to broaden the example and experience base for the concepts introduced in the laboratory and subsequently formalized in the lectures.

Although the philosophy, procedure, format and general approach would be adaptable to meet many different university situations, the curriculum materials were developed based on the needs of our specific students, utilizing the unique skills and background of our faculty. The materials were tailored to our physical facilities and incorporated the available equipment. Activities were under the financial constraints of current departmental allocations.

The most radical departure from the original proposal was the modification of the timetable. The original proposal called for a one year completion schedule. It turned out that we needed an additional year for rewriting and testing of the materials. We are presently undergoing the fourth major draft and trial this fall semester. The project has peeked the interest of the faculty and positive feedback from both faculty and students has produced a determination that will carry successive development and testing into the future.

PROJECT RESULTS

The project has developed a focus around which the 22 members of the Department of Biology have rallied. The problems that plagued the introductory course have been ongoing and esculating in the recent past. Faculty concern had grown to anxiety and frustration after attempts to rectify the situation repeatedly failed. As the FIPSE materials were developed and tested the faculty immediately involved became excited and related their enthusiams to other faculty members and staff. A strong cooperative effort began that started to be rewarded by highly positive feedback from students. This change in attitude concerning the introductory course for majors was one of the most significant results of the project. Appendix D is a copy of the UMSL Magazine that contains an article "They Fall in Love with Themselves" that describes the end result of the project in lay terms.

Students were asked both verbally and in writing how they felt about the way the course was presented and about specific aspects of the curriculum materials. The overall tone of the comments was highly positive. In fact, from the samples taken, there were no direct negative comments. Quotes are included in this report to generate a feeling for student opinions. Representative comments are included only if they were mentioned by 5% or more of the students.

Grading and Evaluation

Grading is fair because you know all of the parts that contribute.
Tests are hard because they ask you to think about ideas in general.
Sometimes the labs were very difficult since we had to come up with the answers ourselves.

Laboratory Materials

I liked working with all of the materials and equipment.
Some labs were too long.
I thought figuring out the answers on my own was great but it sometimes took a long time.

The labs organized my thoughts.
I liked the lab experience most. They were a lot of fun.
The labs were very "student friendly."
The labs helped a lot to understand the lectures.
It is hard to believe that you are allowed to come up with your own answers.
The exercises were easy to follow but could get awfully involved.

Lectures

I still think I like lectures first.
They were well organized and always led to a point.
Most of the time they summarized the labs.
Some didn't follow the book.
It was easy to take notes and they made sense afterwards.
They followed along with the lab well.

Discussion

They were sort of like tests that weren't graded.
It was a good opportunity to find out what you did or didn't know.
I'm not sure they were needed.
It gave everyone an opportunity to summarize what we learned.
Discussions gave us practice with the ideas we learned.

The Course

It was sure different from my high school class.
Everything you did had something to do with thinking.
It was tough but challenging.
The course would be easier if the lectures came first.
_____ made it very easy to understand but she made us think for ourselves.
I feel good about the outcome.
It made me realize I could figure things out for myself.
One of the funnest aspects of the course was understanding how scientific information is obtained.
The class was great because I felt I learned a lot.

Although the statements are not always exact quotes, they are summary statements of feelings expressed by the students of the 1986 winter semester.

In the four semesters prior to the use of the FIPSE materials an average of 10% of the class received F's. This past semester yielded zero failures in a class that contained 9.5% minority students. This is a highly significant indicator of the success of the materials.

In addition, an elaborate plan for a statistical summative evaluation has been drawn up and followed. The questions and instrumentation are as follows.

ANALYSIS OF DATA

1. Is there a correlation between student achievement in the course and study habits score?

   Instrument: Study Habit Inventory and Achievement

   Statistic: Spearman Rho

2. Is there a correlation between student achievement in a course and ratings of previous high school biology course?

   Instrument: SCOR and Achievement

   Statistic: Spearman Rho

3. Is there a correlation between Piagetian level and achievement?

   Instrument: Metric Puzzles and Achievement

   Statistic: Point Biserial Coefficient of Correlation

4. Is there a correlation between subject preference and achievement?

   Instrument: Subject Preference and Course Grade

   Statistic: Spearman Rho

5. Is there a correlation between G.P.A. and course achievement?

   Instrument: GPA at end of semester in which course is being offered, GPA at end of year

6. a) Has students' understanding of increased as a result of course work?

   Instrument: pre-post BSCS, Nelson

   Statistics: t-test (related sample)

   b) Is there a significant difference among the groups (3 semesters) on achievement in content?

   Instrument: pre-post BSCS, Nelson

   Statistics: ANOVA, Newman-Keuls

7. a) Has students' understanding of process skills increased as a result of course work?

   Instrument: pre-post BSCS

   Statistics: t-test (related sample)

   b) Is there a significant difference among the groups (3 semesters) on process skills scores?

   Instrument: pre-post BSCS

   Statistics: ANOVA, Newman-Keuls

8. Is there a significant difference among the groups in the percent of successful students vs. unsuccessful students as a result of the revised course?

   Instrument: Final course grade: Successful - A,B,C;
   Unsuccessful - D, F

   Statistics: Chi-square X^2

9. Is there a significant difference in scores on the Scientific Attitude Inventory as a result of course work?

10. Has piagetian level changed as a result of course work?

    Instrument: Pre-post test, puzzles

    Statistics: Percent of students for whom Piagetian level increased,
    Z test of percent

11. What are demographic characteristics of students in course?

    Instrument: Computer printout

    Statistics: x age; % male - female; % white - nonwhite;
    % public - private schools; % biology majors - others

12. What are demographic characteristics of unsuccessful students?

    Instrument: Class-list and computer printout

    Statistics: x age, % male - female; % white - nonwhite;
    % public - private schools; % biology majors - others

13. Is there a correlation between scores on BSCS and Piagetian level? (both pre and post)

Instrument: BSCS total score and Piagetian puzzles

Statistics: Spearman Rho

14. Is there a correlation between scores on study habits and Piagetian level? (both pre and post)

Instrument: Piagetian Puzzles and Study Habits

Statistics: Point Biserial Coefficient of Correlation

The course data from the pre-FIPSE instructional program will serve as the control and appears as Appendix E. It contains the scores for the various measures for 69 students enrolled in Introductory Biology 10 in the fall semester of 1984. The 75 students in Biology 10 this fall semester will serve as the experimental group, experiencing the complete set of FIPSE sponsored material.

Dissemination of the nature and results of this project have begun and will continue in 1987. The first announcement of the project was in the fall of 1984 through local newspapers and the University bulletin. The first formal presentation was to the Biology Teacher Association, an NABT affiliate in the fall of 1985. A state-wide presentation was made to the Science Education Section of the Missouri Academy of Science in the Spring of 1986 and a sponsored workshop was given to the Association for Biology Laboratory Education Conference group this past spring. A summative presentation entitled "Development of Foundations for an Independent Problem Solving Education in the Biological Sciences" will be given at the National Convention of the National Science Teachers Association in Washington, D. C. in March of 1987.

Copies of the BIO-FIPSE laboratory manual, Biological Investigations for Foundations In Problem Solving Education and the "Lecture Outline for Concept Formation in the Life Sciences" can be obtained by writing the project director and paying the mailing and duplication costs of $28.00. The director and/or members of the initiating team would be willing to consult with interested individuals on the specifics of the project and applicability of transfer to other institutions.

SUMMARY AND CONCLUSIONS

Because of the positive outcomes for both the students and faculty, the project has been a success. It has involved a lot of work, re-education and training, extra hours in preparation and development, and considerable financial commitment. The rejuvenation of spirit and drive were worth the effort in themselves. The major insight that has been gained by the faculty is the realization that a systematic, philosophically based approach to problem solving in science education is as appropriate and effective as it is in science research. Random attempts at course modification are inappropriate and with respect to reaching students and assisting their learning processes.

Those who are interested in this project for their own use must make sure that they have identified the real problems that confront them. If this paradigm appears appropriate then it should be considered for their use but should not consider the specific materials generated the most appropriate for their students and faculty. Some parts may be directly adaptable, others may not. The key seems to be in the individual needs of the students and the expertise and materials that can be brought to bear on the specific situation.

APPENDIX A

INFORMATION FOR FIPSE

APPENDIX A

INFORMATION FOR FIPSE

1. What forms of assistance from FIPSE were helpful to you? How can the Fund more effectively work with Projects?

All of the close interactions with the Fund Program Officers were very helpful. The site visit was important to us and more frequent visits would help to encourage and bolster local efforts. The annual meetings are also important sources of information and support. I believe that each project director should be required to make a formal presentation, perhaps in concurrent sessions, at each annual meeting and give a state-of-the-project report. Each director could share his/her problems and successes with a variety of colleagues.

2. What should the Fund staff consider in reviewing future proposals in your area of interest? What are emerging new directions? What are key considerations, given your type of project?

Proposals should have a sound learning theory base. Mechanical fixes are inappropriate at this time in the development of science education. Traditional course modifications are hard to generalize and disseminate to other institutions. Morever, philosophies of education and learning theory can be used universally and specific mechanisms for their utilization can be developed as local needs dictate.

I think the emerging new direction, with computer-based authoring capabilities, is the development of paradigms that can be computer driven (educational spreadsheets if you will) that will allow local development of specific curricular materials under tested educational philosophies and instructional strategies.

The key considerations seem to be to determine if the problem has truly been identified and possible alternative solutions eliminated. Second, does the proposal apply a defensible learning theory? Third, will the solution address the need within the framework of the educational philosophy?

3. Other Comments

I personally want to thank the Fund for its guidance and its flexibility for creativity. The Fund greatly assists in the professional development of the director and participants as well as providing the umbrella directorate of the projects themselves.

The project has been a very effective instrument in the modification of faculty behavior as well as the introductory course itself. We are proud of the outcome and the effects will reach further into the future than we had dreamed of at the beginning of this task.

Thank you.

APPENDIX B

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APPENDIX B

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THOUGHTS TÓ THINK ABOUT

Introduction

Each of the laboratory experiences associated with this program is planned to introduce you to science as a body of knowledge and science as a process of acquiring knowledge.

Science as a wealth of facts, principles, theories and laws has been uncovered by the curious human being over a long period of time. However, the processes by which the human mind has discovered some of these operational secrets of the universe are more subtle and elusive.

These thinking processes are used and the end results described, but the mechanisms of these thinking processes are unknown. If we reflect on our own history of thought as an individual, we might be able to recall when we were first able to memorize something and repeat back what we learned. Usually this ability is acquired between the ages of 2 and 7 years. Eventually we can apply logical thought or reasoning to concrete problems, that is, for example, we can classify objects, order things, follow recipes and understand concepts that make a direct reference to familiar actions and objects. This stage of mental development is usually attained somewhere between 7 and 11 years. Generally, after this concrete stage people begin to reach the formal stage of mental operations where they can apply logical reasoning where needed to all kinds of problems.

One of the major objectives of this program is to help students move from concrete thought patterns to more formal thought patterns regarding biological phenomenon. It is the purpose here to briefly explore ten of the formal thought patterns that will be emphasized throughout this introductory program. Review the types of reasoning patterns listed here and become familiar with their definitions and examples.

Basic Reasoning Patterns Used in Science

1. Hypothetical Reasoning

   Hypothetical reasoning is the application of thought patterns to relationships, ideas or properties that are not directly observable or directly known; things that are supposed. "If plants were red, what might the photosynthetic action spectrum look like?"

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2. Deductive Reasoning

Deductive reasoning is reasoning from a generalization or theory to a specific situation -- from premises to a conclusion.

A. Generalization or Major Premise: "All cells that lack nuclear membranes and do not have organelles are prokaryotic."

B. Specific Instance Minor Premise: "This cell does not have a nuclear membrane or organelles."

C. Inference or Conclusion: "This cell is prokaryotic."

3. Hypothetical-Deductive Reasoning

Hypothetical-deductive reasoning is logical thought patterns that involve deducing conclusions from hypothesis or assumptions rather than from premises based on facts. "In the evolutionary sequence, suppose birds evolved before reptiles and reptiles before amphibians; then did birds evolve before amphibians?"

4. Inductive Reasoning

Inductive reasoning is the main reasoning process used to derive generalizations or the laws of nature. Specific observations are made and a conclusion that generalizes the common relationships among the observations or facts is developed. "Anatomical structure$_1$ is related to function$_1$. Anatomical structure$_2$ is related to function$_2$. Anatomical structure$_3$ is related function$_3$. Anatomical structure$_n$ is related to function$_n$. Therefore, anatomical structures are related to their functions."

5. Combinational Reasoning

A formal reasoning pattern by which an individual systematically considers all possible relationships of theoretical conditions or situations. "In a dihybrid cross between a plant with smooth and yellow seeds and one with wrinkled, green seeds, what different kinds of zygotic genotypes could be produced?"

6. Propositional Reasoning

Propositional reasoning is used in science to establish whether a hypothesis is true or false. "If amylase is responsible for the chemical digestion of starch into glucose; then glucose will be produced from starch in the presence of amylase." After an appropriate statement of the hypothesis, one can then perform the test and check the accuracy of the hypothesis. During this formal reasoning process the investigator must recognize the necessity of taking all of the known variables into account and design a test that controls all the variables but the one being investigated.

7. Proportional Reasoning

Proportional reasoning demands the recognition of tightly coupled systematic relationships between two variables. "The distance a molecule travels on chromatograph paper is directly related to its solubility in the carrier solution." "The genotype in a single hybrid cross in the second filial generation will yield a 1:2:1 ratio." "After catching 46 fish in a seine, marking them and letting them go and allowing them to mix with the other fish in the pond an investigator re-seined the same area of the pond and caught 72 fish of which 31 had marks. Approximately how many fish are there in the pond?"

8. Probablistic Reasoning

Probablistic reasoning is based on the understanding of chance and proportion. Natural phenomena involve chance considerations. Understanding the normal distribution of attributes of living things requires probablistic reasoning. "Although Mendel's Law of independent assortment dictates the phenotypic ratio in the F_2 generation to be 9:3:3:1 the laboratory results were 345 smooth yellow seeds; 98 wrinkled yellow seeds; 112 smooth green seeds; and 42 wrinkled green seeds. How can you explain these deviant results?

9. Correlational Reasoning

Correlational reasoning allows the investigator to establish a relationship between two or more sets of phenomenon by comparing the number of agreeing instances with the number of disagreeing instances. "The frequency of turns in the honey bee waggle dance is inversely related to the distance the food source is away from the hive." "What relationship is there between gut/trunk length ratios and organism trophic level?"

10. Analogical Reasoning

Analogical reasoning involves the construction of relationships between two things through the inference of a similarity in one area based on a known similarity in some other area. "For example a simple analogy might be: bird is to feather as mammal is to _____?_____ (animal?; skin?; hair?; feet?; arms?; etc.)."

Summary

These ten reasoning patterns are not a comprehensive set of forms of reasoning but do make up a major portion of the types of reasoning skills needed to do science as a process. Through practice of these reasoning skills it is hoped that you will, as a student in Introductory Biology, become effective in dealing with finding solutions to scientifically based problems and broaden your understanding of the basic concepts that are the keys to living systems.

As you work through the various laboratory experiences try to recognize the types of reasoning patterns that you need in order to solve the problems or seek the answers. Make a note of how successful you are in utilizing these mental skills. Remember, it is not whether you got the "right" answer or not that will determine your success in the life science disciplines but whether or not you have a command of the reasoning skills needed to understand and solve problems.

If you are having problems with some of the formal reasoning patterns consult your instructor for assistance. The ultimate question is not "What is the answer?" but "How did you arrive at that conclusion?"

PREFACE

There is more to the development of a biologist or health science professional than memorizing the names and functions of the parts of a variety of organisms, or memorizing facts of any kind about living matter and how it behaves. Certainly a functional knowledge of organisms is important, but the ability to discover new and accurate information is paramount. The ability to utilize knowledge to solve problems and therefore reach new levels of understanding of our living world is the ultimate goal.

This introductory biology manual dealing with basic life science concepts also addresses the development of reasoning skills needed to manipulate the concepts in a problem solving and creative manner. Not only will you learn the basic concepts of the relationship between structure and function, the implications of unity and diversity, energy utilization, homeostasis, heredity, and evolution but you will be required to practice basic reasoning skills such as class inclusion, conservation, serial ordering, combinatorial reasoning, proportional reasoning, propositional reasoning, probablistic reasoning and correlational reasoning.

An underlying theme is the practicing of inductive reasoning, that is reasoning from specific data or observation to general principles or concept that explains the data. Each of the experiences in this laboratory manual will ask you to create explanations of observed phenomena. These explanations or principles of operation are thus built on the concepts that govern the life processes. The inductive reasoning process that you use to develop these concepts is the basic process of discovery and understanding used by scientists in their creative endeavors. When investigators apply these general principles in a new situation then they are performing deductive reasoning, reasoning from the general explanation to a specific observation. The use of both of the major reasoning processes will be required to meet the challenges of these laboratory experiences.

Through the understanding of the biological concepts to be taught and the ability to work with the reasoning patterns introduced in the course, successful students should be able to accept hypothesized statements or assumptions as an initial starting point for reasoning in a hypothetic-deductive manner. In other words you should be able to imagine all possible relations among factors, deduce the consequences of these relations, then empirically verify which of the consequences in fact would occur.

The activities in this manual are specially designed around an educational strategy based on the learning philosophy established by Dr. Jean Piaget, a Swiss biologist and educational philosopher. The teaching strategy is known as the learning cycle. The learning cycle format incorporates an exploratory phase where the student is physically and mentally introduced to a biological phenomenon and given an opportunity to manipulate the system. A second part is the concept introduction phase where the student is led to the formation of a concept that explains how the phenomenon works and links the concept to other meaningful experiences. Thirdly, the students are tested through the application phase to see if they understand the concept and the reasoning behind it well enough to apply it to other problem solving situations.

We expect that this approach to understanding the life sciences and professional preparation may be unusual to you and sometimes difficult. However, we believe that it will be most beneficial to self-development and preparation for your future in the sciences.

We wish you every success in your excursion through these thought-filled activities in the biological sciences.

A. O. W.

C. R. G.

L. D. F.

St. Louis, Missouri 1985

Course Goals and Objectives

B10-Rev/5/23
BIOLOGY 10 F-86

This is an introductory Biology course. Many of you have already been introduced to biology in high school; some of you have never had any biology before but you've had a lot of chemistry. Some of you are looking toward medical school, some of you are just looking around! Many of you are freshmen; some are sophomores, a few are juniors and seniors. In short, you are a diverse group with a wide variety of academic backgrounds and interests.

We're going to be involving you in lecture and in laboratory with some of the major ideas and questions in biology today. In any field there is some basic information that is necessary in order to understand anything at all. Obviously, we'll spend a fair amount of time on information that is pretty well accepted by everyone; for example, cells are surrounded by membranes. But we will then go on to the point where we can say, "Alright, this is what is not known; this is what is controversial, or under investigation." How membranes actually work is a good example of an area currently undergoing a lot of experimentation and revision. Another example is in the field of molecular biology. We think we understand how DNA codes for protein structure, but we are only beginning to get any picture of how the DNA code gets processed to make proteins in anything more complicated than bacteria.

Part of the justification for teaching this course, rather than having you simply jump into the upper level courses in particular areas, is to give you a chance to get some general information in what we would call a conceptual framework. By the time you finish, we hope you will have some understanding of and a feeling for:

1. The structures and functions of the major groups of biological molecules and how one is very closely tied to the other.

2. The structure and function of cells and cellular organelles. The close relationship between structure and function. How molecular structure determines cellular structure and how that makes specialized function possible.

3. The picture, at the molecular level of how organisms get energy - photosynthesis and respiration.

4. How different organisms, in adapting to their different environments, solve the problems common to all living things: nutrient intake, gas exchange, internal transport, homeostasis, information transmission and processing.

5. How genetic information is transmitted from cell to cell, generation to generation.

6. How genetic information in the cell is coded and how it is expressed.

7. How organisms, in the process of adapting to new environments can evolve within species and evolve into new species.

8. How organisms interact within a species, between species and with the non-living components of their environments.

In an attempt to cover the general background information that is needed for an understanding of basic biological processes like those noted above, we will present the course as represented by six themes or principles. These are:

o The process by which living things change through time.	Evolution
o Living things have diverse forms, but there is a unity in patterns and functions.	Unity with Diversity
o A close relationship exists between structure and function in living things.	Structure ∿ Function
o The behavior of organisms and their ability to respond to their respective environments is rooted in biological processes which depend on a supply of energy and a constant interaction of substances.	Energy ∿ Metabolism
o The passing of unique and specific information precisely and continuously from one generation to the next and how this information controls and regulates activities.	Heredity
o Regulation and control permit living things to function in the face of changes in the environment.	Homeostasis

The information that is necessary for the understanding of these principles and their relationships is acquired through a precise approach called scientific inquiry.

It is through the discussion of these principles, guided by scientific inquiry and presented in an orderly sequence of structural organization that we hope you will emerge from the course with an understanding of the basic biological processes that are necessary for the preservation and continuity of living things.

General Grading Format

The course is divided into three parts; lecture, discussion and laboratory.

In lecture there will be four 50 minute examinations tentatively scheduled during the semester and a 3-hour comprehensive final examination at the end. Each of the lecture exams will count for 100 points and the final will count for 200 points. The lowest exam grade (not including the final) will be dropped resulting in a maximum of 500 points that can be achieved in lecture. The laboratory portion of the course must be passed satisfactorily in order to pass the course.

The various assignments in laboratory will total 200 points.

The discussion portion of the course is designed to review the material presented in lecture emphasizing the six principles of the course, thereby enhancing the understanding of basic biological concepts. The number of points achievable in discussion through the completion of a number of assignments and for active participation will total 100. All grades will then be calculated as the percent achieved of the 800 points possible from the three sections of the course.

		Maximum Points
e.g.,	Lecture - 600 points minus one pre-final test	= 500
	Laboratory	= 200
	Discussion	= 100
	Total	800

The point score achieved will be divided by 8 to obtain the percent of the total possible. Letter grades for the semester will then be assigned on the following basis:
A = 85% or over; B = 75 - 84%; C = 65 - 74%; D = 50 - 64%; F = 49% or below.

Students are expected to attend all classes and take all examinations. If examination dates are changed, students will be notified in class. If you cannot attend a class, it is your responsibility to obtain whatever information was given in respect to subject matter and scheduling of examinations from students who did attend the class. A **zero score will be given for an examination which is** not taken. **NO MAKE-UP EXAMINATIONS ARE GIVEN.**

DROPPING THE COURSE

Students are considered to be enrolled in a course through the date of the final examination or until they officially drop the course. To drop a course, you must complete a formal "drop" petition form obtained at the Arts and Science Office, Room 303 Lucas Hall. Students who drop this course prior to the second exam will be automatically excused without a grade. Students who drop this course after the 2nd exam will receive an excused grade only if their overall average score is 50% or above. If their average is less than 50%, the grade is F. According to University regulations, no excused grades are given to students who drop a course after the twelfth week of the semester.

The final grades will not be posted and no one will be available to give this information individually to you. If you desire to know your grade prior to the registrar's official notification, bring a self-addressed stamped postcard or envelope to the final exam and give it to the instructor present. The grade will be mailed to you as soon as it is calculated and recorded. The final exam will be available for your inspection, if you so desire, in the lecture instructor's office approximately three weeks after the exam has been taken. Final exams are not returnable.

B-10 LABORATORY SCHEDULE, Fall - 1986

Week	Dates	Topic
I.	Aug. 25-27	Digestive Systems
II.	Sept. 2-3	Circulatory Systems
III.	Sept. 8-10	Circulatory Systems
IV.	Sept. 15-17	Nervous Systems
V.	Sept. 22-24	Grouping
VI.	Sept. 29 - Oct. 1	Animal Development
VII.	Oct. 6-8	Scientific Experimentation
VIII.	Oct. 13-15	Basic Unit of Life: Cells
IX.	Oct. 20-22	Pigments of Photosynthesis
X.	Oct. 27-29	Heredity and Asexual Cell Division; Statistical Analysis II
XI.	Nov. 3-5	Algal Growth, A Simulation; Experimental Design: Effects of an Environmental Factor on an Invertebrate
XII.	Nov. 10-11	Bacterial Transformation
XIII.	Nov. 17-19	Scientific Testing of Hypothesis: Effects of Environmental Factor on an Invertebrate; Scientific Report
XIV.	Nov. 24-26	Complete Formal Report on Independent Project.
	Nov. 27-28	Thanksgiving Recess
XV.	Dec. 1-3	Population Dynamics

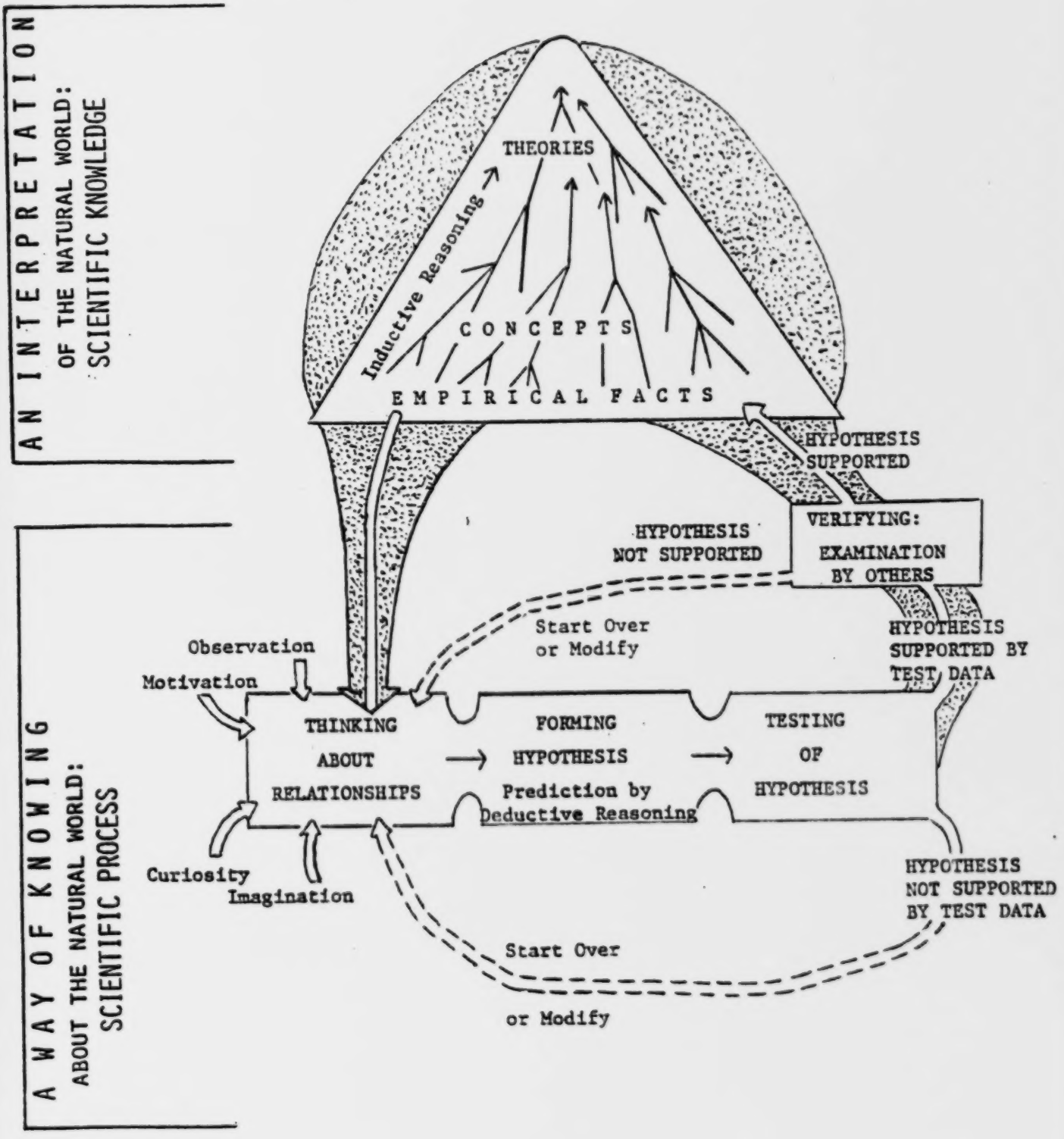
Open Laboratory - Thursdays 1-4:30 p.m.

b-10/6

LEVEL → / PRINCIPLE ↓	ORGAN SYSTEMS/ ORGANISMS	CELLULAR	MOLECULAR	POPULATION	SPECIES	ECOSYSTEMS
1. Structure/ Function	Digestion Gas Exchange Circulation Excretion Nervous Endocrine Reproductive	Organelles Compartmentalization	Atomic Structure Bonding Macromolecules Basic Units	Human Demography	Niche Habitat	Communities
2. Homeostasis	Breathing Rate Heart Rate Blood Sugar Response to Stimuli (Internal + External)	Nuclear Activity Concentration Gradients	Enzymes Gene Regulation	Limiting Factors Carrying Capacity	Communities	Trophic Level Food Webs Symbiosis
3. Energy/ Metabolism		Transport Photosynthesis ATP Production Respiration	Thermodynamics Electrons (Bonding, Storage) Condensation/ Hydrolysis			Energy Flow Nutrient Cycle
4. Unity/ Diversity	Phylogeny Other Organisms	Procaryote/ Eucaryote Types of Cells (Shape, Size, Function)	Emergent Properties		Phylogeny	Food Webs Trophic System
5. Evolution	Adaptation Adjustment to Different Environments	Chromosomal Changes	Mutation Variability DNA-Phylogeny	Microevolution Hardy-Weinberg	Adaptive Radiation Speciation Macroevolution	Succession
6. Heredity	Sexual Reproduction Sex-Linkage Sex-Determination Multiple Alleles	Cell Division Gametogenesis	Replication Complementation Protein Synthesis	Origin of Pops. (Bloodtypes, etc.) (Behavioral Traits)	Pre and Post-Zygotic Selection	

SCIENCE

one of many possible models



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Section_____

DIGESTIVE SYSTEMS AND THE PRINCIPLES OF STRUCTURE-FUNCTION AND UNITY WITH DIVERSITY

PART I: EXPLORATION OF DIGESTIVE TRACTS AND SOME BASIC BIOLOGICAL CONCEPTS

JUST A COMMENT

The charcoal broiled versus grill-fried hamburger controversy in rival advertising for several "hamburger palaces" has no effect on your digestive system when it comes to the digestion of the beef, pickles, onions, ketchup and bun. What does matter is that your tract has the necessary equipment to carry out the digestive activity on the proteins, fats and carbohydrates found in meat, bun, and condiments. We are going to examine some of this equipment to determine how it is built and how it functions.

A. THE DIGESTIVE SYSTEM OF A CARNIVOROUS AMPHIBIAN

A1. The mudpuppy, **Necturus maculosus**, (Phylum: Chordata; Class: Amphibia) has no opportunity to amble down to the local hamburger palace but will eat hamburger meat or a choice insect or two if these can be found in their habitat at the bottom of the rivers and streams in central and eastern United States.

Necturus, is an example of an amphibian which keeps its larval form throughout its entire life instead of changing from the tadpole larva stage to a terrestrial adult like the frog. However, like frogs, the mudpuppy does prey upon animals it finds in its muddy bottom home and, therefore, is called a **carnivore.**

A2. DISSECTION

Open a preserved specimen of Necturus by cutting the abdominal and chest walls as illustrated in Figure 3. Locate a long tube-like structure which is anchored at both the head (cephalic) and tail (caudal) ends. Explore this tube known as the digestive tract. Feel it. Note thicknesses of its parts, expanded areas, constricted areas, and texture of the surfaces. Thoroughly explore openings into the tube visually, with your finger and/or blunt probe. Open the tract by making a cut down its entire length. Note the inner surfaces, any openings into the tract, and double check any judgments that were made about thicknesses of the unopened tract. Check for any other structures and accessory organs that are connected to the digestive tract by small tubes.

A3. Can you detect any differences along the digestive tract? Record your findings in columns A and B of Table I. List the different sections IN ORDER, starting at the anterior (cephalic) end. To help identify the part of the

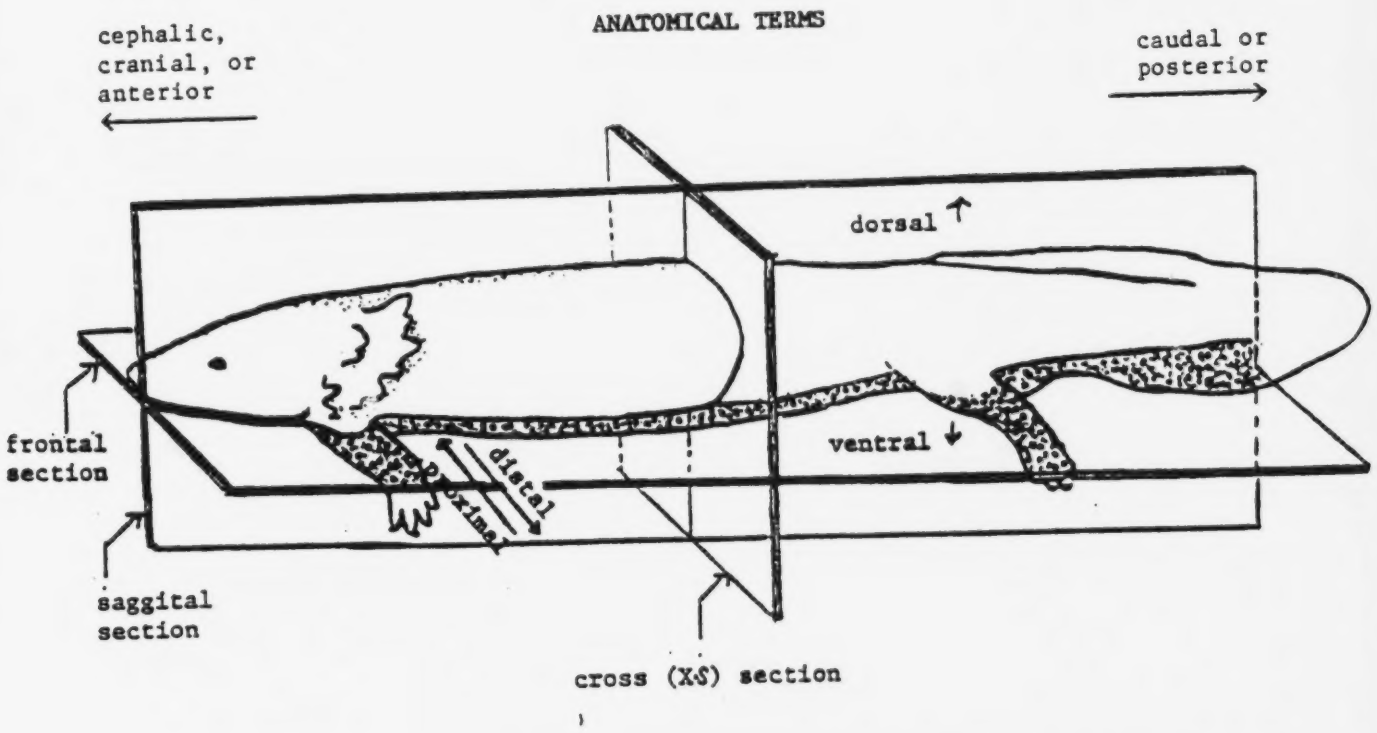


Figure 1. Anatomical Terms Associated With Dissection of Quadraped.

ANATOMICAL VOCABULARY

right and left	- the organism's right and left
anterior	- toward the head (biped, front)
cephalic	- toward the head
posterior	- toward the tail (biped, back)
caudal	- toward the tail
dorsal	- toward the back
ventral	- toward the belly
lateral	- toward the side (right or left)
medial	- toward the middle or center
proximal	- near a specified point of reference
distal	- away from a specified point of reference
pectoral	- referring to the shoulder region
pelvic	- referring to the hip region
superior	- biped, toward the head
inferior	- biped, toward the foot

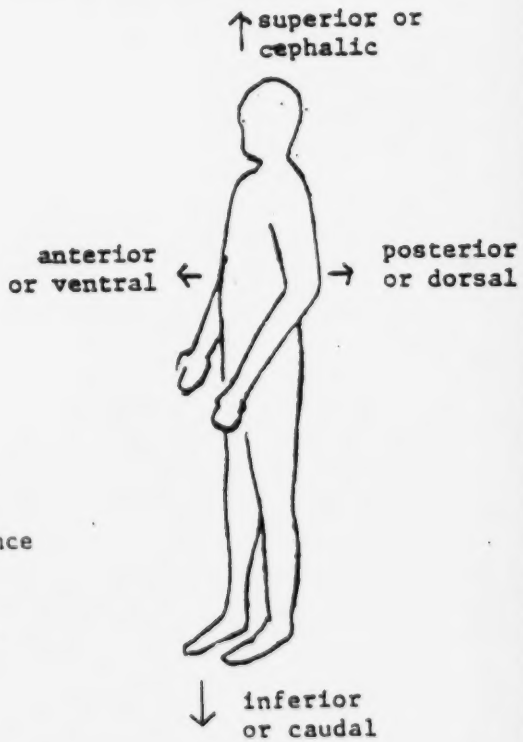


Figure 2.
Anatomical Terms: Biped

A NOTE ABOUT THE TECHNIQUE OF DISSECTION AND SOME OF ITS TOOLS

Dissection and butchering do not use the same technique. The aim in dissection is to separate the structures of the organism from each other so they can be carefully examined, not to cut the organism into eatable chunks.

This means that the cutting tools of SCISSORS, SCAPEL or RAZOR BLADE are rarely used. These tools are used for the initial opening of organisms or opening large internal structures. The major separation tool for macroscopic organisms is the BLUNT METAL PROBE. For smaller organisms, the DISSECTING NEEDLE or GLASS NEEDLE can be used. Many organs are anchored by a thin membrane-like tissue that is easily removed by gentle movement of the separation tool around the structures to be separated.

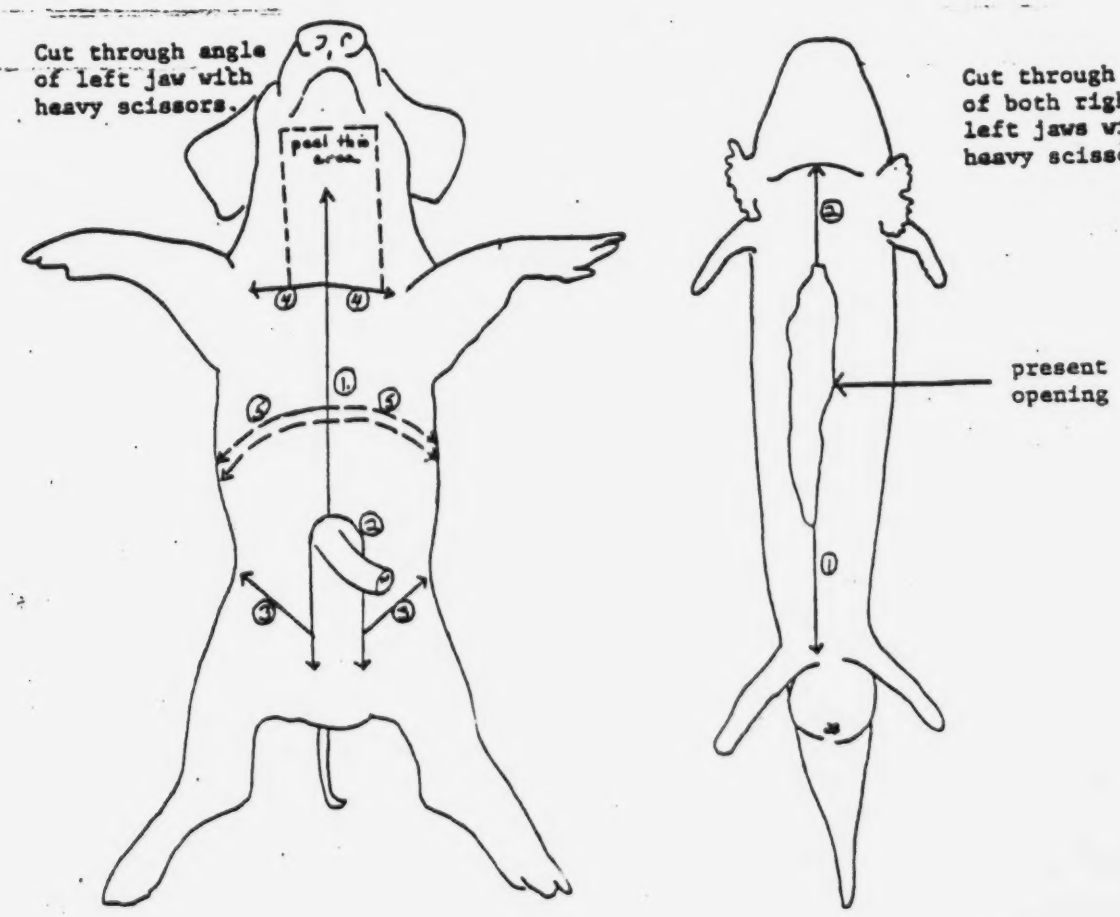

Cut through angle of left jaw with heavy scissors.
peel this area
Cut through angle of both right and left jaws with heavy scissors.
present opening

FIGURE 3. OPENING OF FETAL PIG AND NECTURUS.

Using scissors, keeping blades parallel to organism, cut through ventral walls in the designated order.

TABLE I.
DIGESTIVE SYSTEM OF *NECTURUS MACULOSUS*, MUDPUPPY

A LENGTH OF SECTION ALONG TRACT (in mm.)	B DESCRIPTION OF STRUCTURE AND LOCATION SPECIFICS	C DESCRIPTION OF POSSIBLE FUNCTION	D POSSIBLE NAME OF THE STRUCTURE
2-10 mm from anterior end, in oral cavity	Sharp, hard, lateral and anterior ridges with many backward-pointed conical bumps on dorsal and ventral jaws	Separation of food into small particles by compression of lower ridge against upper ridge; hold active prey.	Teeth
6 to 12 mm in oral cavity	Muscle covered bony projection from mid ventral surface	Limited movement of material in cavity; masher	Tongue

digestive tract which is being described, record the length (in mm) of the different sections along the tract. For curving structures, lay a string along the structure then measure the length of the string. Do not bother with names for these parts now. You can add names to these structures later as an optional activity.

A4. Recall your previous knowledge about what happens in the process of digestion. You probably have more practical knowledge than you realize. In Column C of Table I, try to assign functions to these digestive structures associated with a particular part of the gut. Use the following list of some of the digestive activities, called FUNCTIONS, to supplement your present knowledge of digestive processes. If you have difficulty pairing all of these functions with a part or parts of the tract, do not despair. Pair what you can at this time and return to this task after you have completed some of the other laboratory activities which are designed to increase your working knowledge of digestive processes.

LIST OF FUNCTIONS OF DIGESTIVE TRACT SEGMENTS IN MAMMALS

a. Holds food eaten at one time to be digested later.
b. Proteins broken down to smaller units.
c. Carbohydrates broken down into smaller units.
d. Fats separated into smaller particles.
e. Absorption of small units of broken down food molecules into the blood transport system.
f. Unused food particles are stored for later elimination.
g. Food physically chopped into smaller particles.
h. Food particles churned with digestive juices.
i. Supplying of starch, protein, and fat breaking enzymes by an accessory digestive organ.
j. Houses microorganisms which break down the tough cellulose (a complex carbohydrate) found in plant material.
k. Production by an accessory organ of bile salts, used to emulsify fat.
l. Concentration and storage of bile in an accessory organ.
m. Supplying of enzymes for breakdown of starch by an accessory organ.
n. Movement of food from one structure to another.
o. Movement of food within a structure.
p. Reabsorption of water into the transport system.

B. ANOTHER DIGESTIVE TRACT

B1. A NOTE ABOUT THE ORGANISM: Well known as fish bait and as food for birds, earthworms facilitate the growth of plant roots by turning over soil, making it more porous which allows air to penetrate and water to drain. In their burrowing activity through the soil, the worms swallow soil particles, grind them to small pieces, absorb some of the organic matter as food, and discharge the residue back into the soil. The deposition of processed soil by earthworms was estimated by Charles Darwin to be equal to about a 5 centimeter layer over the entire land surface of the earth every ten years.

B2. DIGESTIVE SYSTEM OF THE EARTHWORM, LUMBRICUS TERRESTRIS
(Phylum Annelida)

Obtain a DORSALLY opened earthworm from the preparation table. You will find many small cross-partitions, septa, which separate the worm into segments. Find and explore the digestive tract of the worm in the same manner used for the Necturus. Record your information in Table II.

TABLE II.
THE DIGESTIVE SYSTEM OF LUMBRICUS TERRESTRIS, EARTHWORM

A	B	C	D
LENGTH OF SECTION ALONG TRACT (IN MM.)	DESCRIPTION OF STRUCTURE AND LOCATION SPECIFICS	DESCRIPTION OF POSSIBLE FUNCTION	POSSIBLE NAME OF THE STRUCTURE

C. DIGESTIVE ACTIVITY, IN VITRO

C1. So far, the exploration of the digestive tracts have been at the macroscopic level. To complete the exploration thoroughly, this tract needs to be studied at the microscopic and sub-microscopic, or chemical, levels. Time is not sufficient to pursue microscopic examinations of digestive tracts, today, but you are encouraged to examine the filmstrip on histology of the digestive system at the A-V center in the laboratory. Some explorations of a few of the chemical activities of the digestive tract will be undertaken in vitro, which means "in glass" or outside of the organism.

Carbohydrates, such as starch, and proteins are two of the types of food molecules in the food we eat. At the demonstration table, observe what happens to solution of starch and the protein of eggwhite as they come in contact with the juices from three portions of the digestive tract, (1) the oral cavity, (2) stomach and (3) the pancreatic tube which connects to the small intestine.

Another type of complex food molecule in our food is oil or fats. Observe what happens to oil when shaken with juice from the bile duct which also drains into the small intestine.

C2. STARCH AND DIGESTIVE JUICES

C2a. STARCH, WATER AND IODINE SOLUTION (I-KI). Transfer starch solution (starch and water) from the labelled dropping bottle to one of the shallow depressions in the white "spot plate". Add one drop of iodine solution from a labelled dropper bottle to the starch in the depression. Record the results in Table III. The results observed with the starch solution occurred as the starch and iodine molecules interacted. Obtaining these results on the addition of I-KI solution to material that might contain starch indicates the presence of starch.

C2b. STARCH AND ORAL CAVITY JUICE. To a second depression add the starch solution which had oral cavity juices added to it. Again add 1 drop of I-KI solution. Record the results in Table III. Compare the result of this test to the result obtained with the plain starch solution.

Is there any starch left in the bottle which also contained oral cavity juices? _____ What evidence was used to determine your answer? _____

_____

_____

C2c. STARCH AND STOMACH JUICE. Repeat the activity of C2b but use the starch solution which had been combined with stomach juice. Record result in Table III.

C2d. STARCH AND PANCREATIC JUICE. Repeat again, using the starch solution which had pancreatic juice added to it.

Please clean, rinse and dry the spot plate, preparing it for the next student.

TABLE III.
DIGESTIVE ACTIVITY

FOOD TYPE	CON-TAINER	FLUID WITH THE FOOD	DESCRIPTION OF THE RESULTS	WHAT DIGESTIVE ACTIVITY IS OCCURRING?
STARCH	A.	water		
	B.	oral juice		
	C.	stomach juice		
	D.	pancreatic juice		
PROTEIN	A.	water		
	B.	oral juice		
	C.	stomach juice		
	D.	pancreatic juice		
OIL	A.	water	10 sec. 1 min. 5 min.	
	B.	water, bile salts	10 sec. 1 min. 5 min.	

C3. PROTEIN AND DIGESTIVE JUICES

Observe the series of tubes which started with the same sized piece of hard boiled eggwhite. These tubes contain the following materials:

A. Eggwhite and water.
B. Eggwhite and oral cavity juice.
C. Eggwhite and stomach juice.
D. Eggwhite and pancreatic juice.

In Table III, describe each tube, specifying any differences observed. Why was Tube A prepared? _____

_____

C4. OILS AND BILE DUCT MATERIAL

Observe the two tubes which contain 3 milliliters of oil. Tube A has water with the oil. Tube B has water plus juice from the bile duct in addition to the oil.

While holding the stoppers with your finger, shake each tube and return to its place in the test tube rack. What happens to the content of each tube after 10 seconds? After 1 minute? After 5 minutes? Record your data in Table III. Does each tube still contain the same amount of oil? _____ Interpret what this means in regard to the possible role of bile duct juice in the digestion of oil.

C5. Utilizing the results from this exploration of digestive activity, return to Table I and Table II and finish filling in any missing information you may have in Column C.

D. OPTIONAL.

The names usually used for these specialized sections of the digestive tract and the accessory organs can be found by consulting references and specimens available in the laboratory and your instructor. These names may be added to Column D of Table I and Table II. Some of the names you might want to consider are:

appendix
anus
caecum
crop
epiglottis
esophagus
gall bladder
gastrovascular cavity
gizzard
glottis
ileocolic valve
intestines, large & small
liver
lysosome
oral cavity
palate, hard and soft
pancreas
pharynx
pyloric valve
rectum
saliva glands
smooth muscle in wall of tract
stomach
teeth
toenail
tongue
tonsils
uvula

E. RELATIONSHIP BETWEEN STRUCTURE AND FUNCTION, FORMING A PRINCIPLE

E1. Review columns B and C of the first two tables. Does there seem to be a relationship between the structure of the different sections of the digestive tract and the digestive activities? _____ Give support for your answer by pointing out several specific examples from your exploration of the Necturus and earthworm digestive tracts.

_____

_____

_____

_____

_____

_____

_____

E2. DO YOU UNDERSTAND THE PRINCIPLE? Ask your instructor to check your tables to see if you have the information that will allow you to understand the basic principle that, **THE ABILITY OF AN ORGANISM TO FUNCTION IN A GIVEN WAY IS DEPENDENT ON HAVING THE APPROPRIATE STRUCTURE.**

PART II: APPLICATION OF THE STRUCTURE-FUNCTION RELATIONSHIP AND MORE EXPLORATIONS

A. DIGESTIVE SYSTEM OF THE FETAL PIG, SUS SCROFA (Phylum: Chordata; Class: Mammalia)

Obtain a fetal pig specimen. This pig may have already been opened, if not, follow the diagram in Figure 3 to open the pig. Explore the digestive tube of this mammal, Sus scrofa. Again associate the digestive functions with a particular structure as you did for Necturus and earthworm. Record your information in Table IV.

B. SIZE OF ABSORPTIVE SURFACE

B1. View the video tape at the audio-visual table demonstrating the effects of the surface area size on the movement of water through filter paper. Record your observations.

_____

_____

_____

B2. In their thinking patterns, humans frequently form general statements, or concepts, from specific observations (inductive reasoning). From your observation of the demonstration you can generalize that: If the surface area across or through which substances are going to pass is increased, then the rate (amount of substance per unit of time) of passage will _____.

Humans also reason from a general concept to new specific situations (deductive reasoning). For example: Since rate of passage increases as surface area increases, then you would predict that an organism which has a structural modification increasing the surface across which digested food passes into the body proper will have a (higher, same, or lower) _____ passage rate than an organism with less surface area.

B3a. Return to the inner surface of the small intestine in the fetal pig. Examine the portion 2-10 centimeters posterior to its origin. What special structures of this surface would permit a larger number of molecules to

cross it? _____

_____

Observe the cross-section of a mammal small intestine on the microscope at the demonstration desk. What did you find?_____

_____

Does this support your macroscopic observations?_____

TABLE IV

DIGESTIVE SYSTEM OF FETAL PIG

A Tube Section	B Anatomical Description and Location Specifics	C Possible Function	D Possible Name For Structure

B3b. Check the sections of digestive tube available on the demonstration table. Put together the location of the breakdown of the big complex food molecules which can be **inferred** from the digestive information recorded in Table III and the surface structure of different portions of the digestive tract just observed. What is your prediction about the location of the movement of **digested food** into the blood stream, the transport system? _____

You have just used a form of thinking frequently used in science, **hypothetical-deductive reasoning.** It involves predicting an unobserved phenomenon from some things known or assumed. Take a moment to think about your thinking process. How did you arrive at your prediction? Explain what specific pieces of information you used and how you linked them together.

_____

_____

_____

B3c. Look again at the intestinal tract of the earthworm and view the cross-section slice of the earthworm's intestinal region on the microscope at the demonstration desk. What is the characteristic of that structure which provides more surface area?_____

_____

C. DIFFERENCES AMONG ORGANISMS

C1. INTESTINAL MODIFICATIONS.

Do both the pig and earthworm have the same intestinal surface modifications?_____
Which one of these organisms would you predict is the most efficient in moving digested molecules into the transport system? _____
Give reasons to substantiate your answer.

_____

_____

_____

C2a. STOMACH? Take another look at the Necturus stomach. What characteristic features do you observe?_____

_____

Does the earthworm have a stomach?_____ How does the earthworm carry on the same activities?_____

_____

C2b. TEETH? What are the functions of the teeth of the Necturus?_____

_____

Does the earthworm have teeth?_____ How can it grind the soil particles that it eats?_____

_____

C2c. Check the model of earthworm anatomy on the model table. Return to your earthworm and recheck the crop and gizzard structures. What could be the relationship between these structures in the earthworm and the stomach and teeth in the Necturus?

_____

_____

Do stop at this point and have your instructor check your progress.

C2d. View the chicken digestive tract on the model table. What does it use for temporary storage of food?_____ To pulverize food?_____ To mix food with digestive fluids?

_____

Chickens have no teeth and, therefore, have to swallow their food whole. Chicken farmers often provide gravel for the chickens to eat. Explain the reason for this practice by farmers.

_____

C3. Would you agree or disagree with the complex statement, "Different animals may have different structures which work in slightly different ways to accomplish similar functions."?_____ Give the evidence from your explorations which support your answer.

_____

_____

_____

A much shorter way of expressing this principle is **UNITY WITH DIVERSITY.** In the case of the chicken, earthworm, pig and Necturus, each have digestive tract structures which can store and grind food. In the pig and necturus it is the stomach and teeth. In the chicken and earthworm it is the crop and gizzard.

C4. In what ways are the digestive system of the fetal pig and the Necturus similar (Unity)?

In what ways are the digestive system of these two organisms dissimilar (Diversity)?

PART III: INDUCTIVE AND DEDUCTIVE REASONING IN SCIENCE

A. INDUCTIVE AND DEDUCTIVE REASONING IN SCIENCE

Scientists are constantly asking questions which try to help us make sense of our natural world. Disciplines in science sort the vast numbers of experiences we have in our natural world into some ordered form so that our minds can deal with these experiences and predict what will be the consequences of other events. In the process of asking questions and predicting future results two reasoning patterns are frequently used. These reasoning patterns are INDUCTION or INDUCTIVE REASONING and DEDUCTION or DEDUCTIVE REASONING.

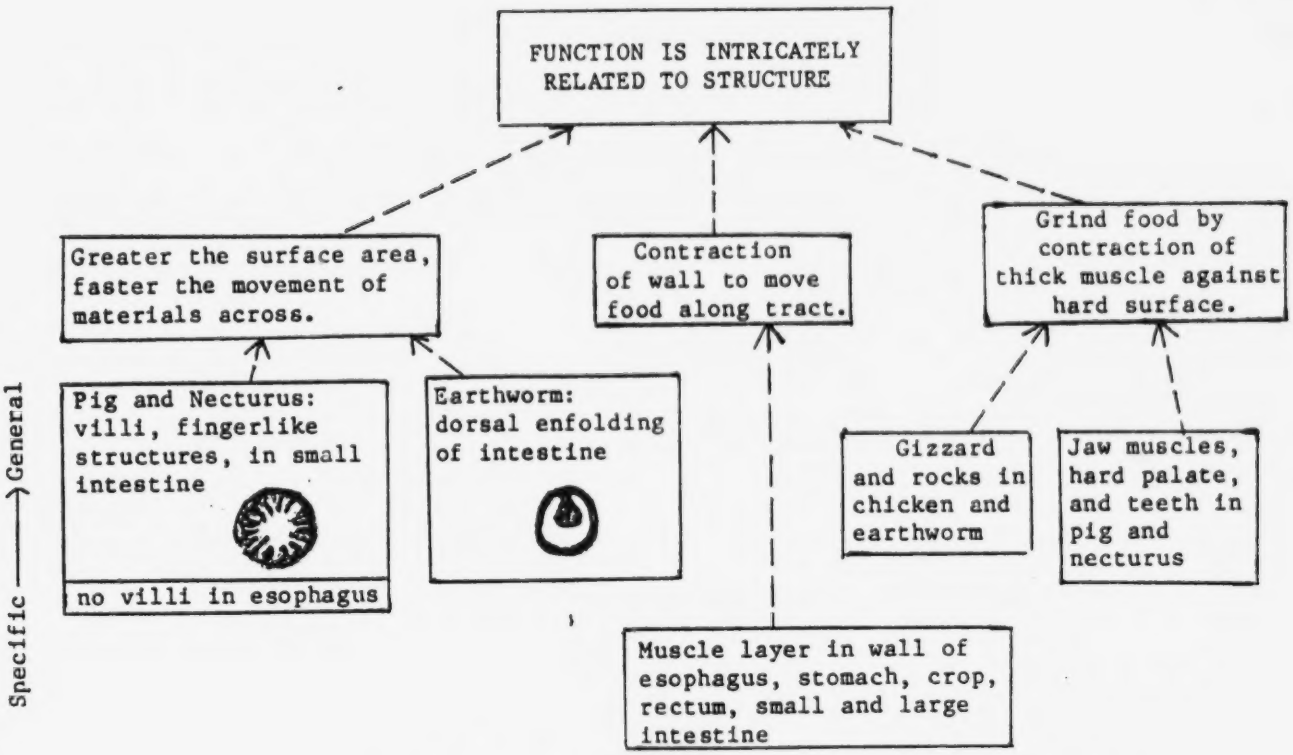
Exploring the digestive tracts of the animals in this laboratory exercise and putting the individual observations together to form the general statement of the intricate relationship between structure and function in living material is an example of INDUCTIVE REASONING. In inductive reasoning, the specific observations or facts are built into a generalization.

Once the generalization of the relationship between structure and function has been formed, scientists use the generalization to predict the results of other events. This gives additional specific knowledge of our world. For instance, if an animal is observed feeding on a large quantity of material and doing it only during the hours around dusk, then the generalization of the structure-function relationship could be used to predict that the feeding organism would have some sort of structure that could hold the food for later digestion. A test of this prediction would be to dissect the organism, searching for such a structure. This is an example of the use of DEDUCTIVE REASONING. In deductive reasoning, the generalization is applied to a new, unknown event.

B. PRACTICE INDUCTIVE REASONING

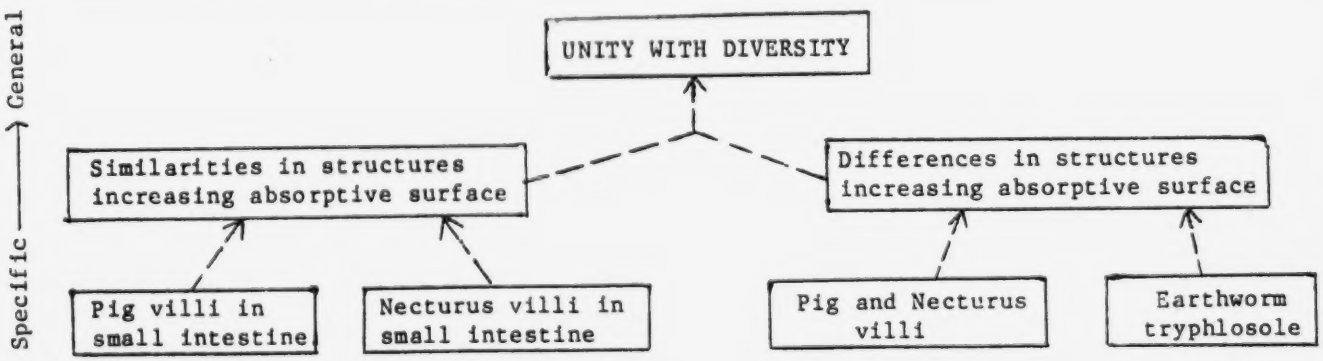
Look back through each of your explorations in this laboratory, write a word or phrase down on a slip of paper which briefly describes each observation, arrange these observations in relationships which can be identified by generalized statements. Build a hierarchy of general statements or concepts into one of the big ideas in biology that relate and make sense out of a lot of experiences. These ideas, we call **principles.** When you have the observations and your general statements arranged into an inductive structure that makes sense (is logical), transfer your arrangement to a sheet of paper and attach to this manual. It should be valuable for your study in preparation for examinations.

EXAMPLES TO HELP YOU GET STARTED


FUNCTION IS INTRICATELY RELATED TO STRUCTURE
Greater the surface area, faster the movement of materials across.
Contraction of wall to move food along tract.
Grind food by contraction of thick muscle against hard surface.
Pig and Necturus: villi, fingerlike structures, in small intestine
no villi in esophagus
Earthworm: dorsal enfolding of intestine
Gizzard and rocks in chicken and earthworm
Jaw muscles, hard palate, and teeth in pig and necturus
Muscle layer in wall of esophagus, stomach, crop, rectum, small and large intestine
Specific → General

HINTS:

In this laboratory two of our six major principles of biology were explored. These are (1) the principle that **function and structure are intricately related** and (2) the principle that living material has **unity with diversity.** Some of your explorations may provide observations for both principles if thought about from different perspectives. In such cases, use the same observation for both principles.


UNITY WITH DIVERSITY
Similarities in structures increasing absorptive surface
Differences in structures increasing absorptive surface
Pig villi in small intestine
Necturus villi in small intestine
Pig and Necturus villi
Earthworm tryphlosole
Specific → General

PART V: ADDITIONAL EXPLORATIONS AND MENTAL GYMNASTICS—OPTIONAL

A. CARNIVORES AND HERBIVORES: THINKING MORE ABOUT THE PRINCIPLES

What is the length of the digestive tract in the fetal pig?_____ In Necturus? _____. What is the ratio of the length of the digestive tract to the length of the animal? Measure length from tip of nose to base of tail. In the pig?_____ In the Necturus? _____ Which digestive tract is longer when compared to the length of the organism?

_____

Animals can be grouped by the type of food they consume. An animal who eats plants is called an herbivore; animals which have both plants and animals in their diet are called omnivores. Pigs are primarily plant eaters but on occasion may eat other animals. As indicated earlier, the meat eating Necturus is a carnivore.

There is a lot of undigestible material, cellulose, in plants. Animal tissue can be almost completely digested.

Does a relationship appear to exist between the relative gut length and the diet of Necturus and organisms like the pig. What is this relationship? _____

_____ Describe the observations which

led to your answer. _____

_____

How can you apply these examples of gut length to body length ratios to the two principles worked on in these labs?

Unity with diversity _____

_____

Structure-Function _____

_____

B. GUT RATIOS AND DIETS

In Table V, are ratios of gut length to body length found in several organisms. With this information, predict which organisms are primarily carnivores and which ones are herbivores.

TABLE V.

RELATIVE GUT LENGTH

Organism	Ratio Gut/Body	Type of Consumer
Snail	6.5/1	
Guinea Pig	5.0/1	
Raccoon	1.8/1	
Mole	2.2/1	
Tapir	4.7/1	
Sea Lion	1.4/1	

C. CAECUM

Neither carnivores or herbivores produce the necessary juices for digesting cellulose. However, in the digestive tracts of some organisms one can find microorganisms, such as bacteria and protistans, which do produce the digestive juices for cellulose breakdown. Some of these organisms have special structure for housing these microorganisms. Is the specialized structure which houses cellulose digesting microorganisms found in both the Necturus and pig?_____

What might be a possible link between the diet of these two organisms and the presence, absence or size of the caecum?

_____

_____

D. A PUZZLE

Look at the preserved sea anemone on the preparation counter during laboratory or discussion period. The sea anemone eats small organisms that swim near it. Does the anemone need to digest food particles?_____ If yes, what structures are used?

_____

If no, how can the anemone survive without something like a digestive tract?

_____

APPENDIX C

LECTURE OUTLINE SAMPLE ON THE CIRCULATORY SYSTEM

THE CIRCULATORY SYSTEM

Part I

TRANSPORT OF NUTRIENTS

I. Umbrella Principle

A. Introduction and Rhetorical Question

Structures so far discussed, have been structures of procurement. The acquiring of the necessary nutrients and oxygen from the external environment. Through processes like diffusion and absorption, these required substances have entered the internal environment. Their ultimate goal, the cells, is yet to be achieved. How do the nutrients and O_2 reach all the tissues and cells of the body? **(Transparency 1)** The answer, of course, is that they are distributed to these cells by the circulatory system.

B. Analogies to Familiar Systems

This system, with some changes, is not unlike a trucking company's distribution route along the network of highways leading to many different destinations. Supplies are loaded on the trucks at a certain location and they then begin moving off down the same road to an intersection where they begin taking different roads to reach their individual destinations. **(Slide 1)** When they arrive at these destinations they unload their cargo, pick up other products and return with these to the central location where they, in turn, are unloaded. They are then ready for another trip.

Airlines also operate in the same manner. Passengers board at the hub or main domesitc flight headquarters (e.g. TWA in St. Louis). **(Slide 2)** The planes take off from the same runway but then begin to fly in different directions to their specific destinations. On landing, passengers deplane, and other passengers board for the flight back to the central hub.

C. Concept Introduction

When the nutrients are incorporated through the wall of the villi of the small intestine of the digestive system and the O_2 taken in through the alveolar membrane, the very next structure they must pass through is the wall of the transport system that will then carry them throughout the body.

II. Concept Application and Examplar Mechanism

A. Overview of System

The transport system is a structure of vessels or tubes that will conduct the nutrients to their eventual destination. Waste products from the cells of the body pass back into the vessels and are then carried to where they will be eliminated from the body.

The system carries both mutrients and waste material. In order to be distributed, the nutrients and wastes are carried along in a fluid that circulates within this system of tubes. **(Transparency 2)** How does the fluid continually circulate? What force is behind the motion or movement of this fluid? Is it necessary for the fluid to flow continually?

Since the cells continually use up the nutrients and O_2 and these substances, therefore, have to be continually supplied, the answer is yes, flow must be continuous. And the way any fluid is continually kept moving is by some sort of pump mechanism. The heart is the pump that keeps the fluid, or blood, flowing in the tubes, or vessels, of the transport, or circulatory system. The transport system, therefore, is composed of three parts: **(Transparency 3)**

COMPONENTS OF THE CIRCULATORY SYSTEM

1. The heart - a muscular pump
2. The vessels - a network of tubes that pass throughout the body
3. The blood - the fluid that circulates within the vessels.

B. Analysis of Specific Components

1. The Piping

The heart and blood vessels are known, collectively, as the cardiovascular system. **(Transparency 4)** Blood moves within this cardiovascular system, leaving the heart through vessels known as arteries. From the arteries, the blood passes into a larger network of arterioles, or smaller arteries. **(X-Section of Blood Vessels)** From the arterioles, the blood is forced through a fine latticework of very narrow, thin-walled tubes called capillaries. Capillaries get their names from the Latin work capillus which means a hair. The exchange of gases, nutrients and waste products between the blood and the cells of the body takes place through the thin walls of the capillaries as the blood flows, squeezing its way through these very narrow vessels. The blood then passes from the capillaries into a third kind of vessel, a small vein or venule, which leads into larger veins that will then carry the blood back to the heart.

2. The Pump

You have been introduced to the heart and its anatomy in laboratory. **(Human Heart Model)** The human heart is a 4-chambered structure made of specialized muscle tissue that contracts and relaxes in a rhythmic manner keeping a constant volume of blood flowing to all parts of the body. **(Transparency 5)** Blood constantly flows into the heart and through the heart's contractions is forced out again to the body. The blood is kept flowing in one direction by structures built into the heart and the blood vessels.

DESCRIPTION OF HEART AND DIRECTION OF FLOW

Let's review the anatomy of the system and indicate those parts that contribute to the unidirectinal flow.

The heart, itself, has two upper chambers, the atria, and two lower chambers called ventricles. The right side of the heart (right atrium and right ventricle) is separated, (isolated structurally) from the left side so there is no mixing of the blood flowing on the right side with the blood flowing on the left side. The blood that is returning from the rest of the body collects in two large veins (the anterior or superior vena cava and the posterior or inferior vena cava) which then empty their contents into the right atrium.

3. The Valves

a. Tricuspid Valve

The blood then passes through an opening into the right ventricle. The opening between the two chambers contains three flaps of tissue supported by string-like cords that attach to muscles in the wall of the base of the ventricle. **(Valve Model)** When the ventricle contracts, the cords loosen, permitting the backflow of the blood to move the thin flaps in place closing the opening between the two chambers just as wind will blow a door shut. This valve action prevents blood from surging back into the atrium when the ventricle contracts. The flap structure is known as the tricuspid valve.

b. Bicuspid Valve

After ventricular contraction, the blood is forced from the right ventricle into an artery (pulmonary artery) leading directly to the lungs. O_2 and CO_2 are exchanged in the capillaries of the lungs (pulmonary capillaries), blood rich in oxygen is returned through large veins (pulmonary veins) to the left atrium of the heart. The blood moves through the opening between the 2 left chambers into the left ventricle. This opening also is controlled by a flap-like structure similar to the tricuspid valve. This valve, however, is made up of 2 flaps instead of 3 and is known as the bicuspid valve. It operates in the same manner as the tricuspid valve and prevents any back flow of blood into the left atrium when the left ventricle contracts. Most of the flow from both atria occurs while the heart is relaxed. When the heart starts to contract, the atria contract first, pushing the remaining 20 percent or so of its blood into the ventricles. When ventricular contraction occurs, the oxygen-rich blood in the left ventricle is forced into a large artery called the aorta which in turn begins to branch into several arteries distributing the blood to the rest of the body.

4. Accommodation of Blood from Ventricles into Arteries

The pulmonary artery and the aorta receive a large volume of blood when the ventricles contract and are able to accommodate this large amount all at once by expanding their walls and increasing their capacity. The muscle contained in their walls will contract to send the blood forward into the other vessels making up the system. There are valves, the pulmonary semilunar valve and the aortic semilunar valve, that lie at the base of the pulmonary artery and the aorta respectively. These valves each consist of three small pockets attached to the inside artery wall. They prevent the backflow of blood from the arteries into the ventricles when the arteries contract thereby sending the blood forward.

a. Arteries

The arteries are thick-walled vessels made up of three layers of tissue. The innermost layer is a thin surface lining of cells. **(Artery Model)** Surrounding this lining is a thick layer of muscle and elastic fibers. These in turn are encased in a layer of connective tissue.

The elasticity that these layers provide to the artery enables it to expand its volume in response to the surge of blood that enters its cavity and to contract with some force helping to push the blood forward. The arterioles are similar in structure but smaller in diameter. The muscle layer that makes up part of the wall is sensitive to the influence of hormones and other substances as well as to nerve fibers. The muscle layer relaxes under the influence of some hormones resulting in a greater increase in blood flow and will contract when stimulated by nerves thereby constricting the diameter of the arteriole and limiting the flow to certain areas of the body.

b. Veins

Veins do not have to accommodate the great pressures that arteries do. The walls of veins are similar in structure to the arteries but have much thinner layers of muscle and elastic fiber. When an artery is empty it remains a hollow tube, like a pipe, **(Vein Model)** but when a vein is empty, its walls collapse like an empty balloon. The veins, however, unlike arteries, have flaps located intermittantly along the inner surface, that act as valves inhibiting backward flow and insuring the continuing one-way progress of the blood through the system.

c. Capillaries

Capillaries have the simplest structure of any vessel in the cardiovascular system. They are thin-walled tubes and on the average about 1 millimeter long which connect the arterioles with the venules. **(Wire Analogy Model)** The entire body is

permeated with a fine mesh of these capillaries that amount to about several thousand kilometers in overall length (0.6 miles/1 km). If all of the capillaries in your body were laid end to end, they would extend across the United States from Coast to Coast. Nutrients, gases and waste materials are exchanged through the capillaries running through the various tissues of the body and the oxygen-poor blood is returned by way of the venous system to the right side of the heart.

5. Pulmonary and Systemic Systems

a. Integration of Components

If we stand back, for a moment, and look at the pattern of events that take place in the distribution of blood throughout the body, we should notice that there are really two separate systems that are part of the distribution process. **(Slide 3)** These separate systems result from the structural separation of the right side of the heart from the left side producing, in effect, two separate pumps. The divided heart permits one side to serve the lungs; and the other side, the rest of the body.

b. Pulmonary System

The right side receives oxygen-poor blood from the body and pumps it through the lungs, where carbon dioxide is replaced by oxygen. The flow from the right side to the lungs and back to the left side of the heart is part of the pulmonary circulatory system.

c. Systemic System

The left side of the heart receives this oxygenated (oxygen-rich) blood from the lungs and pumps it to all parts of the body where oxygen will be exchanged for carbon dioxide before the blood is returned to the right side of the heart. The flow from the left side to the body tissues to the right side of the heart is the systemic circulatory system.

This arrangement is an extremely effective distribution strategy and we will return to this design again when comparing it to other designs that have developed in solving the distribution problem in multicellular organisms.

6. Blood Pressure

a. Mechanisms of Flow

Another impression that we get from looking at the whole structure is that the system is a closed one. There are no openings where either leakage can occur from it or substances can enter it other than through the capillary wall. The blood keeps flowing continuously in one direction throughout

the tube network. The vessels, as we have seen, are not uniform throughout in regard to the diameter of the cavities of the tubes. We also see that while we may have, in fact, a 2-pump system, the distance the blood has to travel from one pump to the other, especially through the systemic circulation, is a long way. **(Transparency 6. Rate Flow)** The flow of blood has to be such that the substances carried by it are transported at a particular rate and amount to be able to supply the right concentration at the proper time and place.

The resistance to flow by smaller diameters of the cavities (producing friction as the flood flows against the walls of the vessels) and by distance are problems that are overcome by the way in which the structure has been built.

The strong, muscular contractions of the heart push the blood out into the elastic arteries which expand in accommodating the large volume of blood forced into them. **(Balloon Model)** When the ventricles relax and the heart is not exerting pressure on the blood in the arteries the pressure would ordinarily fall, but because of its elasticity the artery wall recoils pushing the blood forward and maintaining the pressure. The contraction and relaxation of the ventricles and the expanding and contracting of the arteries produces a pulse-type wave of force sending the blood onwards. This sets up a regular cycle of pressure in the large arteries, the pressure reaching its high point during the peak of contraction of the ventricles (systole) and its low point at the peak of relaxation of the ventricles (diastole).

As the blood continues on in the arterioles it gets farther away from the point where the pressure had originated as well as slowing down because of friction as it passes through smaller vessels. **(Transparency 7. Blood Pressure Data)** The pressure falls rapidly during its trip through the arterioles and capillaries. It continues to decline through the venules and veins and reaches its lowest point in the veins nearest the heart as it is returned slowly to the pump mechanism.

The blood pressure is so low by the time the blood reaches the veins that a mechanism besides pressure from the heart has to be at work in moving the blood. The walls of the veins are thin and easily collapsible. When nearby muscles contract as they move the body and tissues, these structures put pressure on the veins, pushing against their walls and forcing the blood forward. The blood moves only towards the heart when the vein walls are compressed because of the numerous valves in the walls of the veins that shut as blood moves backwards on to them preventing the blood from moving in that direction.

b. Rate of Flow

While pressure continually decreases, the actual rate of flow of blood is slowest in the capillaries and increases somewhat in the veins. This phenomenon occurs because of the tremendously large number of capillaries present. As the blood flows through the arterioles it proceeds at a particular rate. When it enters the vast network of capillaries, the total cross-sectional area increases producing more area for the flow of the blood. **(Cross Section Model)** This situation is comparable to a river running within its channel until it reaches a wider area. The water flows at a slower rate when it has a greater area to do it in. As it then is channelled back to a smaller area the rate of flow is increased through the smaller area for the same amount of water passing through. The network of capillaries provides a greater cross-sectional area in which the blood can flow and it slows down as it passes through this area. When it reaches the venules, the total cross-sectional area decreases and, therefore, the rate of flow increases--even though the overall pressure has decreased.

It is important to be able to have a continual supply of blood flowing past the tissues. In order to keep the fluid moving at the proper pace, the heart has to maintain some rhythm of contraction. It must continually contract and relax and then contract again in a rigidly regulated fashion. Where does this tight regulation occur? How is it controlled? Are there outside (or extrinsic) factors that play a role?

C. Control of Heart Action

1. Intrinsic Control

The heart is actually regulated in two ways: one comes from within the heart itself (intrinsic) and the other is extrinsic.

The initiation of the heart beat comes from within the heart muscle itself and it will continue to beat without any external influences. This intrinsic rhythmic initiation of contraction is basically controlled by a specialized group of muscle cells embedded in the upper wall of the right atrium. This specialized tissue is known as the sino-atrial node (SA) or more commonly as the pacemaker. The SA node sends out electrical impulses - similar to nerve impulses -- that spread across the atria causing them to contract. **(Transparency 8. SA & A-V Diagram)** The same impulse reaches a second nodal area, the atrioventricular node (AV) located farther down in the right atrial wall near the border of the ventricle and slightly towards the midline. From this region the impulse is propagated rapidly over a special network of fibers called the bundle of His. The passage of this wave triggers the almost simultaneous contraction of all the cells of

the right and left ventricles. The cells of the AV node are of smaller diameter than the rest of the muscle in the area which causes about a tenth of a second delay between the atrial and ventricular contractions. This delay permits the atria to finish emptying their contents into the ventricles before the ventricles start to contract.

2. Extrinsic Control

While the heart can contract and pump blood without outside influence, it must respond to varying oxygen needs and changing blood pressure in the organs and tissues it serves. Extrinsic factors like the nervous system and hormones have their influence on the heart permitting the necessary adjustments to be made. These factors can change the rate of heartbeat, increasing or decreasing the intrinsic rate that is originally initiated by the SA node.

3. Monitoring the System

The knowledge one has about the makeup of the structure as it is related to the functioning of the system enables one to examine the events that occur by monitoring certain aspects of the heartbeat. The simplest way to monitor heartbeat is to listen to the heart at work. The first sound you hear, a low-pitched dub, is the closing of the bicuspid and tricuspid valves at the start of ventricular contraction. A little later you hear a higher-pitched dub, the closing of the semilunar valves at the end of ventricular contraction. If the valves are not closing fully, or if they open too narrowly, turbulence is created within the heart and a sloshing sound may be heard. This is a so-called heart murmur and indicates the malfunctioning of the valves. The degree of murmur would indicate the extent of damage. Slight murmurs are almost normal and can function normally under most circumstances. **(Demonstration)**

A second way to examine the events of the heartbeat is to monitor the blood pressure. During one part of the heartbeat, the atria are filling and contracting. At this time, the pressure in the arteries leading from the left side of the heart out to the tissues of the body decreases slightly as the blood moves out of the arteries, through the rest of the system and into the atria. This period is referred to as the diastolic period. During the contraction of the left ventricle, a pulse of blood is forced into the systemic system, immediately raising the blood pressure within these vessels. This pushing period, which ends with the closing of the aortic semilunar valve, is referred to as the systolic period. Blood pressure values are measured in millimeters of mercury, just like atmospheric pressures. In other words, they reflect the height to which a column of mercury would be raised in a tube by an equivalent pressure. **(Demonstration) (Illustration of Sphygmomanometer Measurement)**

A third way to monitor the happenings during a heartbeat is to measure the electric changes that occur. In the course of contraction, the heart muscle undergoes a series of electrical changes. These changes can be detected by electrodes attached to the skin and can be graphed by a device called an electrocardiograph (EKG). The EKG indicates the time and intensity of the atrial and ventricular contractions and relaxations.
(Demonstration)

Biology 10 Lecture Schedule Fall 1986

Date		Topic	*Readings
Aug. 25, 27	I.	Orientation and Introduction	Chs. 1, 2(42-44), 15 (p. 282-283)
	II.	Maintenance and Regulation	
Aug. 27, 29		A. Digestion	Ch. 43
Sept. 3		B. Gas Exchange	Ch. 44
Sept. 5, 8, 10		C. Transport	Ch. 45
Sept. 10, 12, 15		D. Nervous	Ch. 46 (p. 987-1000, 1007-1009) Ch. 48 (p. 1032-1038)
Sept. 17		E. Endocrine	Ch. 48 (p. 1039-1044) Ch. 40 (p. 860-863)
Sept. 19		F. Excretion	Ch. 48 (p. 1044-1055)
Sept. 22 (M)		**EXAM I**	
	III.	Diversity	
Sept. 24		A. Taxonomy	Ch. 22
Sept. 24, 26, 29 Oct. 1		B. Animal Kingdom	Chs. 35, 36, 37, 38
Oct. 1, 3, 6		C. Plant Kingdom	Chs. 29, 34 (p. 695-707)
Oct. 8		D. Fungi	Ch. 28
Oct. 8, 10		E. Protists and Monerans	Ch. 27, 26 (p. 511-515, 518-523)
Oct. 13 (M)		**EXAM II**	
	IV.	Chemical and Cellular Basis of Life	
Oct. 15, 17		A. Atomic Structure	Ch. 2
Oct. 17, 20		B. Macromolecules	Ch. 4 (p. 55-65, 68-79)
Oct. 20, 22, 24		C. Cells	Chs. 4 (p. 66-67), 5, 6, 8, 9
Oct. 27		D. Energy Transformation	Ch. 10
Oct. 29		E. Energy Release	Ch. 11
Oct. 31		F. Energy Acquisition	Ch. 12
Nov. 3 (M)		**EXAM III**	
	V.	Inheritance	
Nov. 5, 7, 10		A. Patterns of Inheritance	Ch. 13 (p. 237-247, 250-258), Ch. 14 (259-268, 270-280), Ch. 40 (863-868)
Nov. 12, 14		B. Molecular Biology	Chs. 15, 16 (301-314, 319-321)

Nov. 17, 19, 21	C. Mechanisms of Evolution	Chs. 19, 20, 21
	VI. Ecology	
Nov. 21, 24	A. Populations	Ch. 52
Nov. 24, 26	B. Communities	Ch. 53
Dec. 1, 3	C. Ecosystems	Ch. 51
Dec. 5 (F)	**EXAM IV**	
Dec. 10 (W)	**FINAL EXAM (Comprehensive)** (12:30 p.m. - 3:30 p.m.)	

***Reading Assignments:**
Raven and Johnson, 1986, Biology, Times Mirror/Mosby, Missouri

B-10 Lab Disk 2/15

BIO-Rev/6-Doc-10

Biology 10: F-86

General Lecture Outline

I. Introduction

A. Science and the Scientific Method

1. Concept: Scientific study is dependent upon a process of inquiry, testing, repeating and communicating information.

a. Ways of doing science

i. Scientific method

ii. Paradigms

iii. Darwinism

B. Study of Life

1. Concept: Pattern and arrangement of material determines whether it is living or non-living.

Questions: 1. Certain properties are also necessary for material to be living; does the arrangement also determine all of these properties?

2. What are the properties necessary to differentiate between living and non-living?

a. General properties

i. Growth and development

ii. Regulation

iii. Response to stimuli

iiii. Reproduction

v. Adaptation

b. Unity vs. diversity

C. Levels of Organization

1. Concept: Life is put together in a complex and highly organized fashion.

a. The structure of life begins at the molecular level and proceeds in a hierarchal fashion to include all living forms and the physical environment that supports them.

i. Atoms, molecules, organelles

ii. Cells, tissues, organs, organ systems

iii. Organisms, populations, communities, ecosystems

iiii. Biosphere

D. Fundamental Principles

1. Concept: Certain principles are indigenous to Life and occur for the most part on each level of organization.

a. Principles related to living things

i. Structure/Function

ii. Unity/Diversity

iii. Energy/Metabolism

iiii. Homeostasis

v. Heredity

vi. Evolution

b. Course consists of discussion of these principles and how they operate and interact with one another at each level of biological organization.

II. Human Physiology (Organizational level - Organism)

A. Acquiring Nutrients - Food

1. Concept: Breakdown of large substances into smaller ones for utilization

Questions: 1. Why is breakdown necessary?

2. How does breakdown proceed?

a. Review metabolism as a principle of life

i. Necessity for breakdown - macromolecules to simpler components

ii. What is needed for breakdown -

Processes: 1. Mechanical

Mastication, Churning, Peristalsis

2. Chemical

Catalysis (Enzymes - specificities, etc.)

2. Concept: This process (function) is influenced by the structure in which it takes place.

Questions: 1. Is there much of a difference in structure within the system?

2. What are the specific functions of the system? (Breakdown and absorption)

3. What specific anatomical features of the structure relate to the functions?

4. Does the particular habitat and life-style of an organism affect the structure--and, in turn, the function?

a. Refer to organisms used in laboratory - Necturus, Earthworm, Fetal Pig

b. Description of events using the human system

i. food moving through from the mouth to the anus

- overview of physical actions

ii. Chemical action in sequential order of events

- Introducing absorption, ingestion, egestion

- relating to events like ulcers, heartburn, etc.

c. Adaptation of organism, depending on habitat and life-style

i. Development of digestive systems

- Diffusion, incomplete systems, complete systems

Refer back to earthworm, etc.

Comparison (due to diet) of herbivores and carnivores

d. Summary: Acquisition of fuel

i. Ingestion

ii. Digestion

iii. Egestion

iiii. Relationship of system to circulatory system

3. Concept: Acquisition of nutrients (like O_2) accomplished by specialized structures adapted to this specific function.

a. Explanation of importance of acquiring O_2 and most cases (animals) the elimination of CO_2.

b. Description of the human breathing system

c. Explanation of mechanisms involved

i. concentration gradients - including negative pressure, partial pressure of gases, increased surface area.

d. Other systems

i. Planaria - diffusion

ii. Insects - tracheal system

iii. Amphibian - positive pressure

e. Summary - Acquisition and release of gases

Relationship of system to circulatory system

B. Transport of Nutrients

1. Concept: Nutrients are transported by way of the Circulatory System to all parts of the organism.

Questions: 1. What kind of structure needed?

2. Would flow have to be continuous?

3. If so, in what way would flow be maintained?

4. Is blood made up only of nutrient substances?

5. How does exchange of substances take place between the circulatory system and other parts of the body?

6. Do different habitats affect the structure?

a. Relate to structure as demonstrated in lab

i. the direction of flow of blood through each of the component parts.

ii. Reinforcing idea (from lab) on pulmonary and systemic circulations with the sites of exchange of gases and nutrients and how they relate to this structural plan.

b. Description of blood flow characteristics and ability to monitor action thereby acquiring information about the operation (sounds (valves), blood pressure, EKG.)

c. Components of blood

i. Active participants within circulatory system

j. Cellular components

RBC (function), WBC, Platelet

jj. Fluid components (Plasma)

Proteins (Fibrinogen, Globulin, Albumin)

ii. Passive components

j. Nutrients - Food, Gases

jj. Vitamins, hormones

d. Exchange mechanisms in capillaries

i. Emphasize concentration gradients

j. Hydrostatic presure

jj. Osmotic pressure

ii. Intercellular fluid

Role of Lymphatic System as balance to Circulatory System

e. Roles other than transport of Circulatory System

i. Defense

j. Antibodies

jj. Phagocytes

ii. Regulation

j. Temperature

jj. Pressure (Osmotic fluid)

f. Other systems -

i. Open vs. closed

ii. 2,3 and 4 chambered hearts

g. Summary:

Role of Circulatory System

i. Transport - Relation to other systems

ii. Defense

iii. Regulation - Relation to other systems

C. Elimination of Wastes

1. Concept: Metabolic waste materials must be eliminated from the organism through a process known as excretion.

Questions:
1. What kind of structure is involved?
2. What is its relationship to the Circulatory System?
3. Through what mechanisms does excretion take place.

a. Description of the system

i. Kidney

j. macroscopic

jj. microscopic - nephron system

b. Review of mechanisms involved

i. Hydrostatic pressure (filtration)

ii. Active transport

iii. Secretion

iiii. Counter - current process - using fish as another example.

2. Concept: Through the process of excretion, the kidney is also involved in regulation of blood-water volume, adjustment of blood pressure and control over all blood chemistry (pH and ion level).

Questions:
1. What is the relationship of excretion in the kidney to homeostasis involving other systems?
2. By what processes does this regulation occur?

a. Description of negative feedback process and building on this process to present

i. blood-water volume relationship (Osmotic pressure) - Role of ADH

ii. sugar and amino-acid concentrations - tying the role of the kidney to that of the liver.

b. Other systems - Comparative

c. Summary

Role of excretion and regulation

Reviewing relation with other systems and the processes by which the excretory system functions.

D. Endocrine System

1. Concept: The endocrine system maintains homeostasis by integrating internal conditions and coordinating responses through substances secreted into the bloodstream.

Questions:

1. What are the mechanisms by which the system communicates?
2. What are the controls regulating this system in relation to its homeostatic role?
3. How do the endocrine substances (hormones) directly affect the tissues it operates on (target tissues)?

a. Description of system

i. structure of glands - endocrine vs. exocrine

ii. target organs - description and indication of function

b. Regulatory role

i. balancing of concentration gradients in negative feedback manner.

j. Trophic hormones (Pituitary)

jj. Pancreatic hormones

jjj. Anti-diuretic hormone (Osmotic Press. - ADH)

c. Relationship to Nervous system

i. Coordination and association

j. Anterior pituitary structure

Portal system, releasing factors

jj. Posterior pituitary - storage, neurosecretory substances

d. Mechanisms of operation

i. Steroid - target cell interaction

ii. Protein - target cell interaction

iii. Multiple function - Neurotransmitters

e. Summary

i. Transmitted via bloodstream

ii. Regulatory in function

E. Nervous System

1. Concept: The nervous system maintains homeostasis by integrating internal and external conditions and coordinating responses through a cell to cell system.

Questions: 1. How does the system communicate within its own structure?

2. How does it communicate with other systems?

a. Description of neurons

i. Parts of the neuron

ii. Areas between neurons (Synapse)

b. Organization of overall systems -

i. Central Nervous System

j. Brain

jj. Spinal Cord

ii. Peripheral System

j. Cranial nerves

jj. Spinal nerves

iii. Autonomic System

j. Sympathetic

jj. Parasympathetic

jjj. Ganglia

c. Processes

i. Electrical

j. Membrane potential (Concentration gradients)

jj. Polarization

ii. Chemical (Neurotransmitters)

j. Synaptic transmission

iii. Pre and post-synaptic transmission

d. Neural function

i. Reflex arc - several everyday examples

stimulatory (withdraw from painful stimulus),

inhibitory - (balancing reflexes, etc.) and

facilitation - (sensitive sometimes, less so at

others)

ii. Brain

j. anatomy and function

jj. Associations

e. Comparative systems

Major phylum differences

(Coelenterate, flatworm, insect, earthworm, vertebrate)

f. Summary

Review of processes of communication and regulatory role.

(e.g. autonomic control of heart rate)

F. Integration of Systems

Overall summary emphasizing homeostasis using examples previously discussed such as heart rate, breathing rate, bloodsugar, etc.

III. Diversity

Concept: Organisms can be grouped in categories based on similarities and differences of characteristics.

Questions:

1. With so many different kinds of organisms, by what means can they be organized?
2. What different criteria are used to help differentiate or catalog the organisms?

3. What similarities can be determined between the different groups?
4. Do these similarities indicate particular relationships?

A. Taxonomy

1. Historic approach

a. Referring back to different kinds of organisms.

b. Simple criteria for cataloging

(Use non-biological examples of classification; then biological ones)

c. Discussion of Linnaeus and his approach

d. Description of classification system - from general to more specific (i.e. Kingdom ——> species)

B. Phylogeny

1. Five Kingdom Scheme

2. Animal Kingdom - Major phyla

(Review types from previous comparative systems)

3. Plant Kingdom

a. Major differences

b. Adaptations

i. Aquatic, terrestrial

ii. Non-vascular, vascular

c. Physiology

i. transpiration

ii. translocation

4. Fungi - Saprophytes

5. Protistans and Monerans

6. Introduce symbiotic theory as possible way of producing eukaryotic cells.

Emphasis on structure-function, adaption throughout Kingdoms.

General Lecture Outline

Level - Molecular

IV. Building Materials of Life

Concept: The atoms of a given element differ from atoms of all other elements in the number and arrangement of their protons, neutrons and electrons.

Questions: 1. What is the structure of the atom?

2. How does it interact with other atoms?

A. Atomic Structure

1. Elements

2. Chemical and physical properties

3. Energy levels

Concept: A chemical bond is an energy relationship.

Questions: 1. What types of interactions can occur between atoms?

a. Bonding

i. Ionic

ii. Covalent

iii. Hydrogen

b. Chemical reactions

c. Storage of energy

Introduce: Molecules, ionization, acids and bases (pH)

Reinforce: Diffusion

B. Macromolecules

Concept: Simple units are built up into larger, more complex substances.

Questions:

1. What are the differences between inorganic and organic substances?
2. What are the functions of these different types of organic structures?
3. How do the chemical reactions occur?

1. Basic Units
2. Build-up - Condensation
3. Breakdown - Hydrolysis
4. Catalysis - Allosterism

Concepts of emergent properties and negative feedback reinforced.

V. Building Blocks of Life

Concept: The cell is the basic living unit of organization for all organisms.

Questions:

1. What are some of the features necessary for a structure to be considered living?
2. What is it about the structure of the plasma membrane that provides for its many functions?
3. How do procaryotic cells differ from eucaryotic cells?
4. What are some of the structures of the eucaryotic cell and their functions?
5. What are the advantages and disadvantages of mitosis and meiosis?

A. Structural organization and aspects of function

1. Three structural features that are necessary for maintaining the living state in all cell types.
   a. Plasma membrane - Physical boundary (passage of substances), selective permeability and detection of environmental changes.
   b. Region containing material and instructions for synthesizing the organic substances required for growth, development and reproduction — nucleus or nucleoid.
   c. Internal membranes (compartmentalization) and particles located in the cytoplasm that function in metabolism.

B. Variety

1. Shape - Different shapes provide for different functions - lining, secretory, nervous, etc.

2. Size - Surface to volume ratio important in determining shape, size and multicellular configuration of cell and/or organism.

C. Major Types

1. Prokaryotic

a. Major areas or regions

Plasma membrane, nucleoid, cytoplasm

2. Eukaryotic

a. Major areas

Plasma membrane, nucleus, cytoplasm

b. Organelles (Individual function)

i regulation and control

ii transport

(macromolecules - general types and characteristics)

Reinforce concentration gradients

iii Modes of cell division

iiii Energy conversion and storage and energy utilization (in general non-molecular ways) introducing concepts of thermodynamics, coupling reactions, photosynthesis and respiration.

VI. A. Utilization of molecules in metabolism

Concept: The build up and breakdown of molecules within the cell is a continual process that provides the necessary materials and energy for maintaining life.

Questions:
1. Why is energy necessary for maintaining life?
2. How does the cell acquire energy?
3. How does the cell utilize energy?

1. Reinforce thermodynamics including forms of energy, conversion of energy, etc.
2. Discussion of electromagnetic spectrum, absorption spectra.
3. Photosynthesis - acquisition and conversion of light energy into chemical energy. - Review bonding, ATP molecule, carriers, light and dark reactions.
4. Respiration

   Glycolysis, Krebs Cycle, and electron transport system

Transition: Control, Regulation and Programming

B. Continuity of Life

Concept: All of the activity that goes on in the cell is controlled and regulated by DNA.

Questions:

1. How does the DNA remain constant in its information from generation to generation?
2. How is the information translated into activity?
3. Is there flexibility in the kind of information that is transmitted?
4. What are the long range advantages and disadvantages in the ability to modify the structure?

1. Genetic material - DNA - Structure, historical development
2. Structure related to processes
   a. Replication
   b. Information processing (protein synthesis)
   c. Modification of structure (mutation)
      - Introduce concepts: origin of new types, complementation, genes
      - Reinforce: Variability, mitosis and meiosis in more detail

   Transition and Integration of Cellular and Organismal Levels

3. Asexual and sexual processes incorporating the concept of variability including changes in the information involved in the continuity of life, concepts of mutation, chromosome aberration. (General description of mitosis and meiosis)

VII. Transmission of Life

Concept: The characteristics of life are transmitted from generation to generation through structures known as genes.

Questions:

1. Why did Mendel succeed where others had failed to determine the process and mechanism by which inheritance of traits occurred?
2. What are the relationships that can develop between genes (alleles) for the same trait?
3. Do these relationships change between genes for different traits?
4. What rules or guidelines can be set down related to procedures based on Mendel's experiments?

A. Blending Inheritance (History)

B. Particulate Inheritance

1. Segregation Inheritance (Monohybrid)

   Include terms: Dominant, recessive, alleles, genotype, phenotype, heterozygote, homozygote

2. Independent Assortment (Dihybrid)

3. Multiple Alleles

   a. Blood groups

      ABO, Rh

   b. Coat color in mammals

      e.g. Chinchilla - demonstrating allelic hierarchy

C. Chromosome Basis

Concept: Genes are located on structures known as chromosomes. Chromosomes form the basis for inheritance of all characteristics.

Questions:

1. Do all inherited phenomena follow Mendel's rules?
2. What is the significance of the relationship between chromosome inheritance and cell reproduction?

1. Sex determination

   - Reinforce: Meiosis through discussion on non-disjunction

2. Other Chromosomal aberrations

   a. Down's Syndrome

   b. Other examples

3. Sex-linkage

   a. Human examples

   b. Calico cat - Reviews non-disjunction, sex-linkage and Lyonization

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Level: Population

Transition from individuals to collections of individuals of the same kind - (Populations)

VIII. Group Interaction

Concept: The survival of a population depends upon its size, structure and distribution.

Questions:

1. What factors influence population size?
2. How important is the parameter of size to a population?
3. Can the principle of homeostasis be applied at the population level?

A. Human demography

Examples of human populations - mostly third world.

1. Growth curves

   a. Limiting factors

   b. Carrying capacity

2. Stability of Populations

a. Doubling time

b. Age structure

B. Origin and history of populations

1. Blood groups used as examples for evidence of origin and migration of populations.

C. Microevolution

Concept: When a population is evolving, its gene frequencies are changing through successive generations.

Question: What are the factors involved in this change?

1. Gene pool
2. Gene frequency
3. Application of Hardy-Weinberg Equilibrium
4. Founder effect

- Reinforce: Variability within populations

Transition to concepts of population changes and speciation

IX. Interaction Between Groups

A. Macroevolution

Concept: The origin, mechanisms and consequences of interactions between groups and their environments represent the basis for evolutionary change.

Questions:

1. What forces are at work providing for the separation of one group into two or more different groups?
2. Is this process necessarily always a long, slow process?

1. Adaptive radiation
   a. migration
   b. population pressure
2. Speciation
   a. isolation factors
   b. pre-mating selection
   c. post-mating selection
3. Patterns of change among populations
   a. Divergence
   b. Convergence
   c. Parallel

Level: Communities

B. Interaction between populations

Concept: Populations do not exist by themselves but interact with other different types of populations (species) to form communities.

Questions:
1. Are the interactions between species beneficial or detrimental to their survival?
2. Do these interactions relate directly to the reproductive success of populations?

1. Habitat
2. Niche

3. Interactions

   a. competition

   b. symbiosis

   c. predation

   d. coevolution

Level: Ecosystem

X. Cycle of Life

A. Interdependency - Ecosystems

Concept: An ecosystem is a delicate relationship consisting of living and non-living components in which the living are dependents on a continual supply of nutrients and energy which they use and transfer among themselves.

Questions:

1. What factors are used in determining an organism's position in the cycle of events that take place in an ecosystem?
2. By what means and in what state are energy and nutrients available in each part of the cycle?

1. Trophic levels

   a. Producers

   b. Consumers

   c. Decomposers

2. Food webs

3. Energy flow

4. Biogeochemical cycles

B. Succession

Concept: By virtue of its own survival each community changes its environment making it more attractive to different species thereby providing the opportunity of its own demise and the rise of an entirely different community.

Questions:

1. What factors do species contribute to alter the environment making it less fit for that type of organism?
2. Do all species or communities contribute in this way to ensure their own instability?
3. How does a community reach the status of long-range stability?

1. Adaptation
2. Transition
3. Climax communities

XI. Summary

Review the fundamental principles related to living material indicating how each occurs at every level of organization utilizing the concepts covered.

APPENDIX D

UMSL MAGAZINE

UMSL

THE MAGAZINE OF THE UNIVERSITY OF MISSOURI-ST. LOUIS
SUMMER, 1986

INSIDE: The "new" Biology 1

They Fall in Love with Themselves

Students in UM-St. Louis' "new" Biology 10
are learning how to think and they love it.

by Mary Costantin
Mary Costantin is manager of the Office of Public Relations.

For years, Biology 10, the rigorous one-semester introductory biology course for students at the University of Missouri-St. Louis who intended to major in biology or a health-related science, had been turning out a lot of winners who went on to do well in their majors and in their careers. But, at the same time, a disturbingly high number of apparently capable students in the course—about 45 percent of the total enrollment each semester—weren't making it. They were pulling Ds and Fs or dropping out.

The biology department felt frustrated. The content of the course couldn't be altered since it is the foundation for the rest of the students' training. Yet, the loss of so many students who had intended to make biology the focus of their life's work was unacceptable to faculty members. It was especially unacceptable to them because the University of Missouri-St. Louis, the sole public university in the St. Louis area, represents the only opportunity many students have for obtaining a college education. But attempts to reduce the attrition rate in Bio 10, without jeopardizing academic standards, had met with little success.

A recently concluded three-semester experiment, reworking the way that the department teaches Biology 10, may, however, provide a solution to the problem—which is by no means unique to the UM-St. Louis campus. Dr. Charles R. Granger, professor of biology and chair of the biology department, directed the project, which was supported by UM-St. Louis and an $81,000 grant from the Fund for the Improvement of Postsecondary Education (FIPSE). An award-winning teacher, Granger has taught science on every level from elementary school through graduate school and, as a professor of education as well as of biology, he is involved in the training of science teachers.

"I firmly believe," he says, "that it is how material is presented to a student, not the inherent difficulty of the material itself, that influences a student's ability to learn. The changes we've made in the way Biology 10 is taught are specifically designed to develop student skills in synthesizing concrete knowledge into formal concepts and in utilizing these concepts to solve related problems."

What they're doing in Biology 10 is teaching students how to think.

About 45 percent of the students each semester weren't making it.

Each week the students start with a three-and-one-half-hour laboratory experience, attend three hours of lecture, and spend an hour in a discussion session where a senior faculty member meets with a small group of the students to reinforce and apply the concepts presented in the lab and lecture. A visitor observing the students—at work in the lab or in class with Dr. Lawrence Friedman, associate professor of biology, or in an impromptu discussion with Anne Wilke, director of undergraduate biology labs—comes away with several strong impressions. The students are relaxed, even though there is an exam just over the horizon; they have an air of shared purpose with the faculty; and they are intensely interested in what's going on. You can almost hear the wheels turning in their heads.

In his office, a few days later, Granger agrees with these observations.

"They know the course isn't easy, yet they find themselves 'getting it,' so they're not crippled by anxiety," he adds. "Then they discover they can take what they've learned and use it to figure out related problems. You've seen them in the lab. They don't sit there anxiously waiting for someone to tell them what to do next or if they've gotten the *right* answer. They are confident that their observations are correct, and they just keep going until they develop an explanation."

The "new" restructured Biology 10 is based on the learning theory of Swiss biologist Jean Piaget and the work of others who have used it to develop learning cycle teaching strategies.

Piaget groups development of the learning process into four stages, the first two of which are developed in early childhood. The third stage—concrete logical operations—involves patterns of reasoning applied by the individual to directly observable objects, their properties or their simple relationships. The fourth stage—formal operation—includes more complex thoughts and reasoning skills which do not require the presence of concrete objects or their properties.

Piaget theorized that a learner moves from concrete to formal reasoning through a transitional phase that is basically experience-practice, experience-practice, experience-practice. Since, physiologically, most people have the capacity for formal reasoning by the time they're 14, high school seems the logical place for that period of practice.

How material is presented influences a student's ability to learn.

"Our students come to us with educational backgrounds that cover the spectrum," Granger explains. "It takes experience to develop that capability, and some of them just haven't had it. But traditional college teaching, including the 'old' Biology 10, assumes the student is already an experienced formal reasoner.

"Since analysis had shown that 80 percent of the goals in this course required formal reasoning patterns, we decided to test the introductory biology students enrolled at that time [1984] to find out at

what stage their reasoning skills actually were."

The results paralleled studies done earlier on college freshmen at other universities: 25 percent of Biology 10 students were formal reasoners, 25 percent were in the transitional stage, and 50 percent, a figure close to the course's attrition rate, were still at the concrete reasoning level. Further analysis showed a high correlation between the students' level of success in the course and their ability to use formal reasoning patterns.

The Biology 10 team—Granger, Friedman, and Wilke—sat down and went to work, researching and mapping out a way to teach the course that would provide students with experiences and encounters, starting from the concrete, that would develop or strengthen their formal reasoning capabilities so that they would be able to internalize the fundamentals of biology, instead of just memorizing them. FIPSE, which turns down 97 percent of the proposals it receives, came through with a grant, and the deans of the University's Graduate School and the College of Arts and Sciences pitched in to help get the project underway.

Friedman and Wilke were each given a semester's leave: Friedman to revamp the lectures and Wilke to redesign the laboratory sessions. Procedures were devised to evaluate the project's effects on the students' cognitive development.

Finally, on January 21, 1985, the first students in the "new" Biology 10 course sat down to a two-hour battery of pre-instructional tests.

How do the students feel about the "new" Biology 10?

One indicator may be that, in the third and final semester of the experiment, for the first time in the history of the course, enrollment of students at semester's end was up—a substantial 18 percent up—over the number of students enrolled at the beginning of the semester. Would-be biology majors, it appears, are voting with their registrations in favor of Biology 10.

The rest of their life is affected for the better.

"It's an interesting phenomenon to observe," says Granger. "As the course goes on, you see the students developing confidence in their ability to reason and, well, they just fall in love with themselves. They really like this person who knows what he or she is doing. They have confidence in their mental skills, and, of course, the rest of their life—not just here at UMSL—is affected for the better."

Numerous letters of inquiry have shown considerable interest among educators in the new Biology 10 strategy, and the results of the experiment will be presented at major education meetings this fall and winter. Meanwhile, Granger has another experiment underway, the Partnership Outreach Program in Science Education (POPSE), a program that will bring the learning cycle teaching strategy to science students in several area high schools. Love—and understanding—may soon be sweeping the country!□

UMSL Grad's Impact on Education

For Sarah Caldwell (Ed.D., '79) no two days are alike. As assistant superintendent of secondary education for the Webster Groves School District, Dr. Caldwell is involved in a variety of administrative functions and directly supervises the curriculum for over two hundred teachers and support staff and two thousand students in grades seven through twelve. She sees her present challenge as helping a highly regarded secondary school program become even better.

"Today you must be committed to strong ideals or the educational challenge can become overwhelming," she explains.

She sees her role as providing leadership to the district in continuing and enhancing their staff development programs. Since about 80 percent of most school budgets go for staff salaries, it just makes good sense to Dr. Caldwell to protect that investment in people with programs to ensure that the Webster Groves teachers are in touch with and capable of taking advantage of all the current research that is being done in education.

She strongly endorses the master teacher concept and has recently published an article in the *Elementary School Journal* describing the Webster Groves district's experience with implementing this concept. This article, "The Master Teacher as Staff Developer," was Dr. Caldwell's 12th published article in the last five years. She attributes this strong interest in educational writing and research, in part, to her experiences as a graduate student at UM-St. Louis.

"It was a rigorous program," she remembers. "Quite frankly, there were many activities that I resisted at the time, but I know I can look back and clearly see their positive impact on my professional and personal growth."

Research and writing have become a way of life for her since her days at UMSL.

"Until I teach something or write about it, I don't know it," she says.

Sarah Caldwell is one of 23 individuals that have received the Doctor of Education degree from UM-St. Louis.□

APPENDIX E

EVALUATION REPORT

INTRODUCTORY BIOLOGY 10

CONTROL DATA

Fall, 1984

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Introduction

The evaluation portion of this report will focus on program outcomes. The data sources and results are discussed in three sections based on semesters. These semesters are fall, 1984, spring, 1985 and fall, 1985.

The purpose of this research is to reduce the number of students who fail to successfully complete the introductory biology course, Biology 010. In particular, attention was focused on the failure of a disproportionate number of minority students, 75%, to complete this course successfully. This research attempts to reduce the failure rate by assisting in the development of the formal reasoning patterns needed for success in the course. This was to be accomplished through the use of the learning cycle.

Research Design

A quasi-experimental, cohort design was used in this study. The design is outlined below:

O_1	X_1	O_2
O_3	X_2	O_4
O_5	X_3	O_6

O_1 = pretest scores Biological Science Curriculum Study (BSCS) - Fall, 1984, B-10

X_1 = lecture-laboratory format - traditional

O_2 = posttest scores, BSCS - Fall, 1984

O_3 = pretest scores, BSCS - Spring, 1985

O_4 = posttest scores BSCS - Spring, 1985

X_2 = learning cycle format, Spring, 1985

O_5 = pretest scores, BSCS - Fall, 1985

X_3 = learning cycle format, Fall, 1985

O_6 = posttest scores, BSCS - Fall, 1985

Semester - Fall, 1984

Population and Samples

The population consisted of all students enrolled in the Introductory Biology:10 course at the University of Missouri-St. Louis (UMSL) during the 1984, fall semester, day sections. Demographic data for these students are listed in Appendix A at the end of this report. The accepting sample consisted of all students who reported to the experimental class sections during the first week of class. The data producing sample consisted of those students who remained enrolled in the class four weeks after the 1984, fall semester began.

Table 1 and Table 2 provide descriptive data for the accepting sample.

Table 1

Descriptive Data for the Accepting Sample, B10 - Fall, 1984

Sex	Number	Mean Age	Percent White	Percent Nonwhite
		DAY		
Male	28	21.3	38	2.9
Female	41	20.1	46	5.8
Total	69	20.7	84	8.7

Table 2

Descriptive Data for the Accepting Sample, B10-Fall, 1984

High School		Declared Major	
Percent Public	Percent Private	Percent Biology	Percent Other
74	26	57	43

Instruments and Summary Statistics

During the first four weeks of the 1984, fall semester, the students took a battery of 13 tests. These tests were divided into three major areas: Piagetian level, cognitive and affective. The tests taken in each area are listed below. This section will discuss each test and a summary of the results for each test will be presented. Appendix B presents an overall summary of each students' test results. The tests used to assess Piagetian level were:

a) Burney's Piagetian Objective Formal Instrument[1]

b) Metric Puzzle[2]

c) Apartment Puzzle[3]

d) Mealworm Puzzle[4]

e) Island Puzzle[5]

The tests used to assess cognitive level of achievement were the:

a) Biological Science Curriculum Study Test (BSCS)

b) Nelson Biology Test - Revised Edition Form E

The tests used to assess affective levels were:

a) Study Habit Inventory

b) Scientific Attitude Inventory

c) The Science Research Temperament Scale

d) Science Classroom Orientation Resolutionnaire

e) Subject Preference Questionnaire

f) Creativity Test

Affective Instruments

The Study Habit Inventory written by C. Gilbert Wrenn has as its purpose to test for those attitudes and habits that are conducive to study. It is a weighted checklist of 28 habits and attitudes which high and low scholarship groups of students possess in differing proportions. The test is divided into four parts, A =

reading and note-taking techniques, B = habits of concentration, C = distribution of time and social relationships in study, and D = general habits and attitudes of work.

The student indicates whether each habit characterizes him rarely, sometimes or often. Positive or negative scores are provided for each answer for each item. A negative score means more students of low scholarship than of high scholarship have checked the item the same way the student did. A positive score means the habit is more indicative of a high scholarship student. The average total score of the sample of college freshmen used to standardize the test was +15. The maximum and minimum scores for each part are indicated below.

A = Reading and Note-taking Techniques

Maximum = 43
Minimum = -37

B = Habits of Concentration

Maximum = 23
Minimum = -53

C = Distribution of Time and Social Relationships in Study

Maximum = 57
Minimum = -68

D = General Habits and Attitudes of Work

Maximum = 62
Minimum = -91

A summary of the results obtained for the 1984, fall semester of the study is presented in Table 3.

Table 3

Summary Data for Study Habit Inventory - Fall, 1984

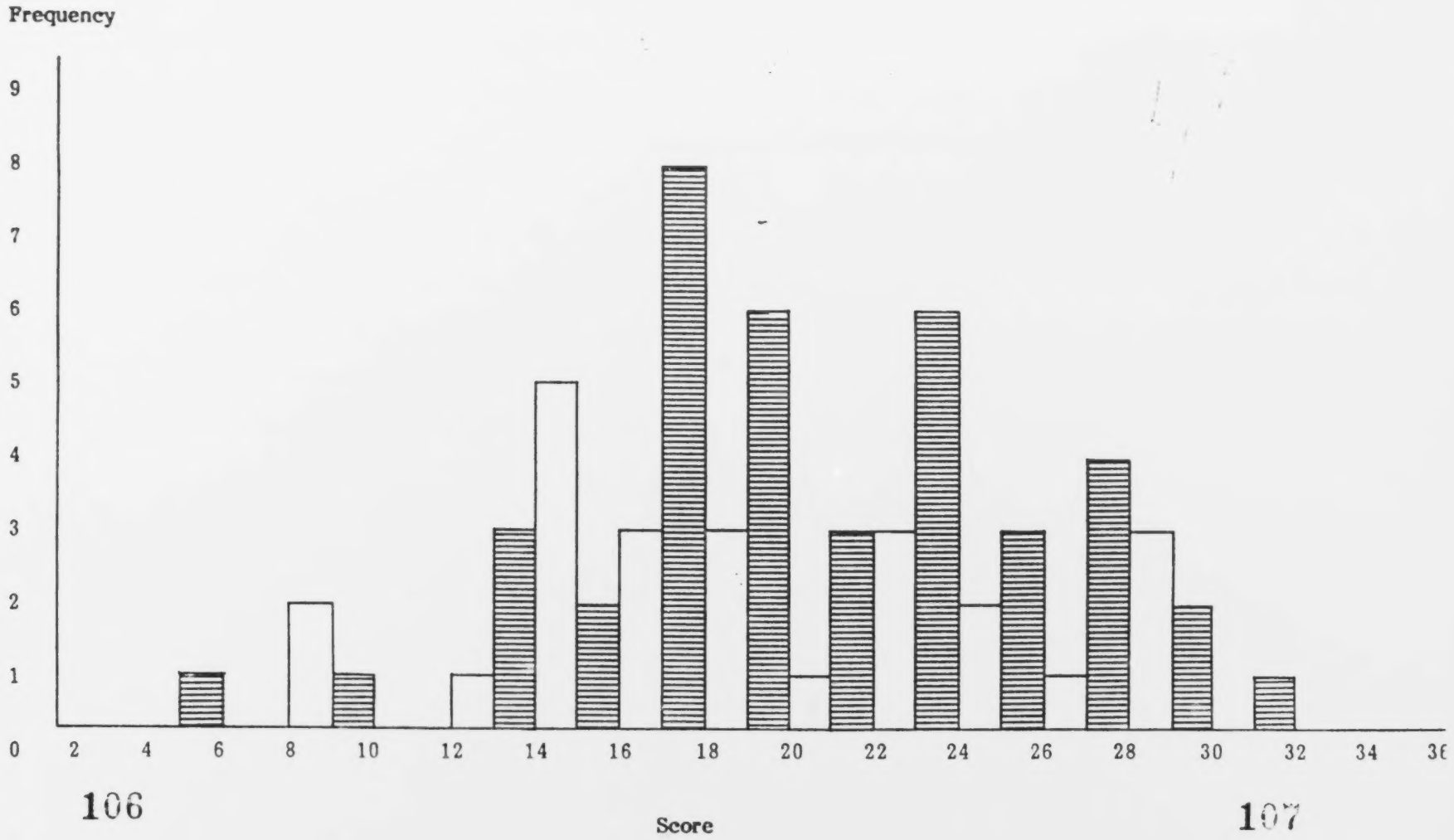
	Test Section			
	Part A	**Part B**	**Part C**	**Part D**
Mean	2.11	1.37	19.9	7.77
Range	-23 to 35	-19 to 17	-43 to 52	-36 to 54
N = 69				

The Science Research Temperament Scale (SRT) was developed by William C. Kosinar to aid in identifying those personality traits associated with research productivity. The test consists of forty-two paired traits. The traits were paired on the basis of equal social acceptability but different discriminative ability. The highest score possible is 42 and the lowest score possible is zero. Very low scores suggest the presence of personality traits that act as retardents to research productivity. High scores suggest traits that are conducive to research productivity.

The SRT was standardized using a group of 310 research workers. The mean score for this group was 18.5, the median was 17.7 and the mode was 15. The mean score for the 64 students enrolled in B10, fall semester, was 19.5. The median score for this group was 19 and the mode was 17. Figure 1 presents a summary of the results obtained for the 1984, fall semester.

Figure 1

Frequency Distribution of Raw Scores for SRT



The Science Classroom Orientation Resolutionnaire (SCOR) was developed by one of the researchers to assess the students' perceptions of the science activities that occurred in their high school science classroom. It consists of thirty true and false items. The maximum possible score was 30. The mean score for the 1984, fall semester sample was 14.5. A high score indicates a science classroom where the students were encouraged to engage in the higher process skills of analysis, synthesis and evaluation. Figure 2 summarizes the results obtained for the 1984, fall semester.

The Subject Preference Questionnaire is a two part instrument developed by one of the researchers. Part I of the instrument contains sixteen items consisting of two choices. The student is directed to choose which of the two subjects listed as choices is the preferred subject. One of the choices is always science. Part II consists of sixteen items, two choices, one of which is science. In this part the student is directed to choose the subject that is more important to the general welfare of man. Figure 3 and Figure 4 summarizes the results of the Subject Preference Questionnaire for the 1984, fall sample. The mean score for Part I was 13.03. The mean score for Part II was 11.15.

Figure 2

Frequency Distribution of Raw Scores for SCOR

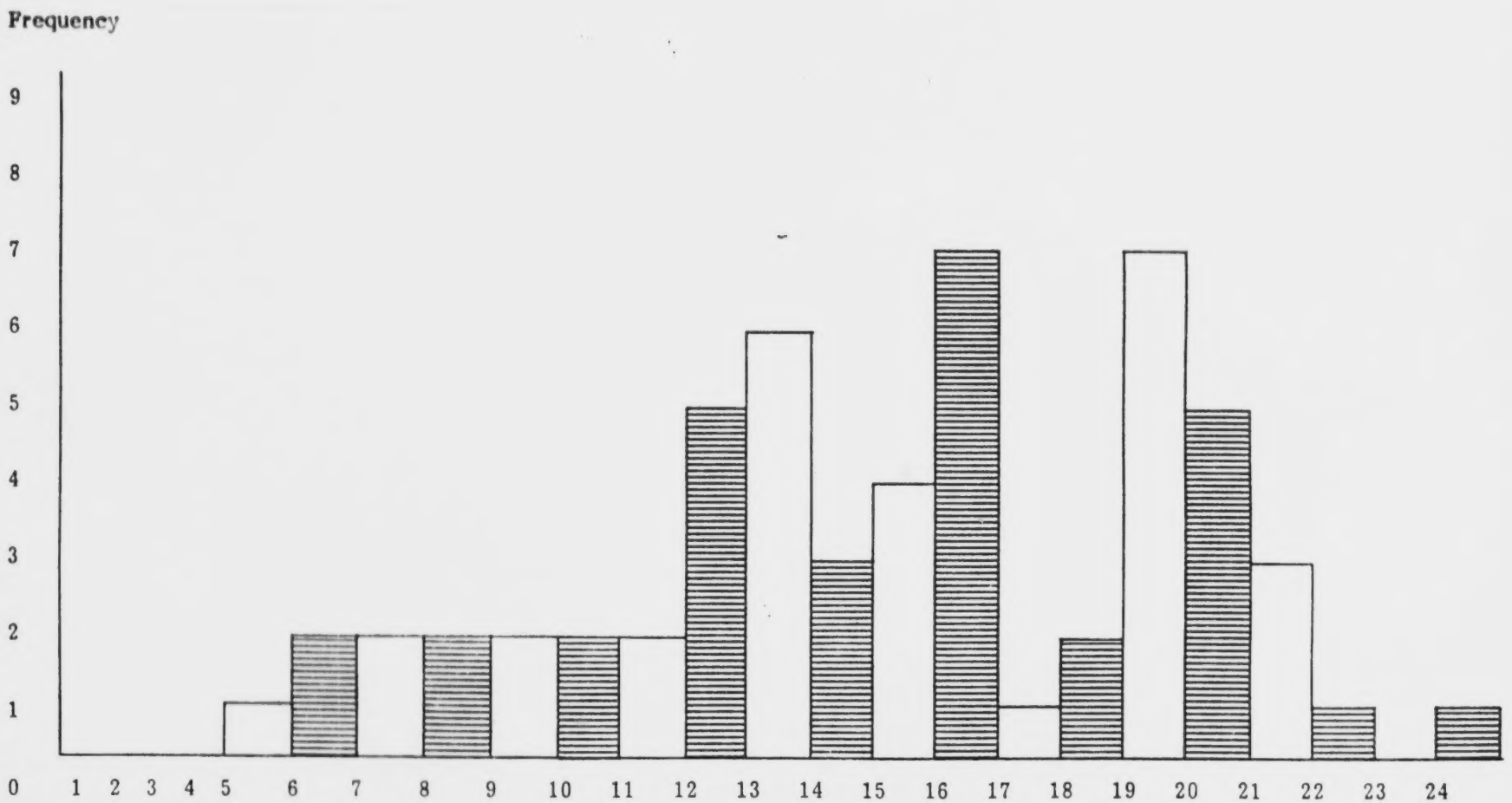


Figure 3

Frequency Distribution of Raw Scores for the
Subject Preference Questionnaire - Part I
Fall, 1984

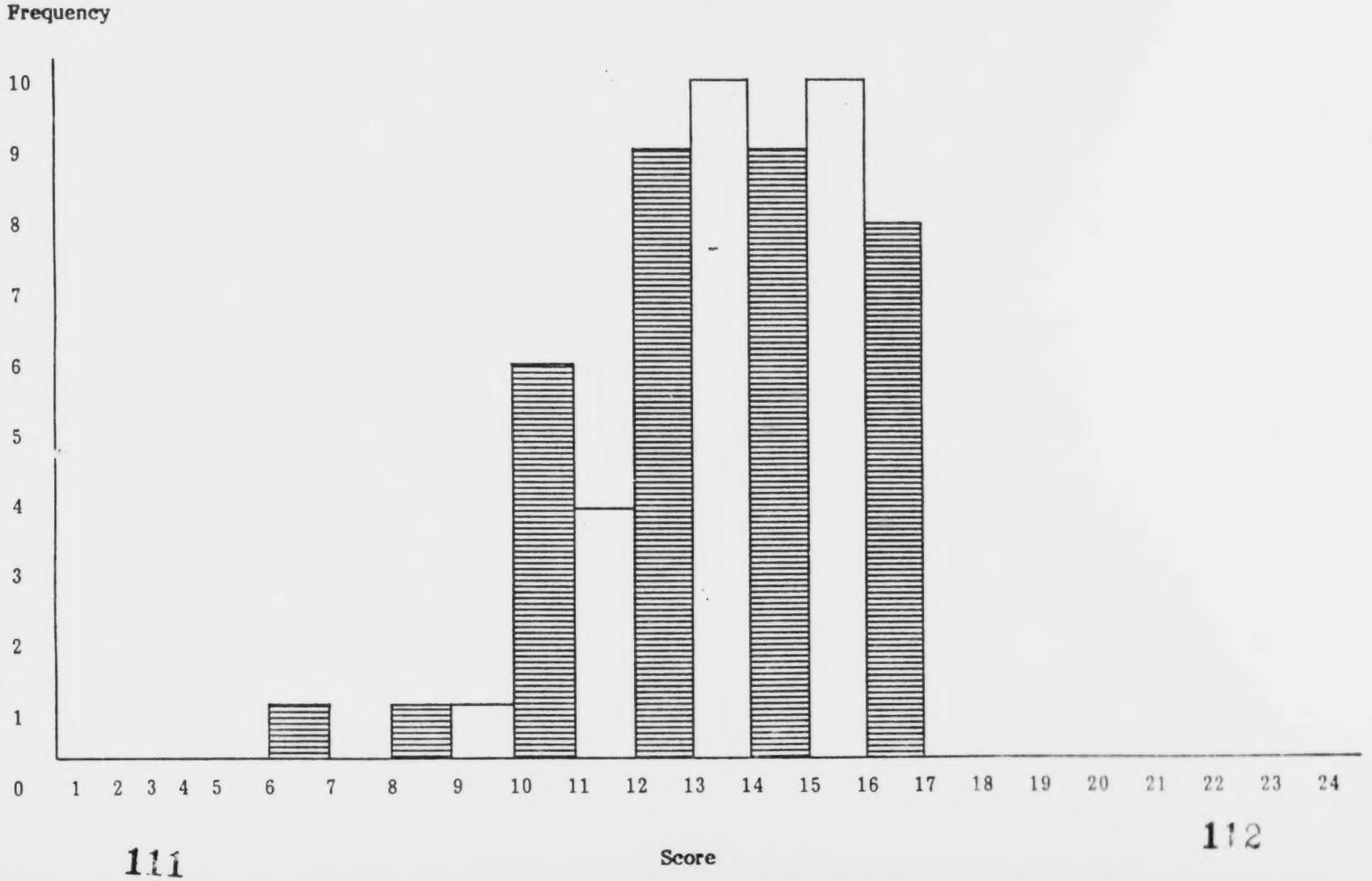
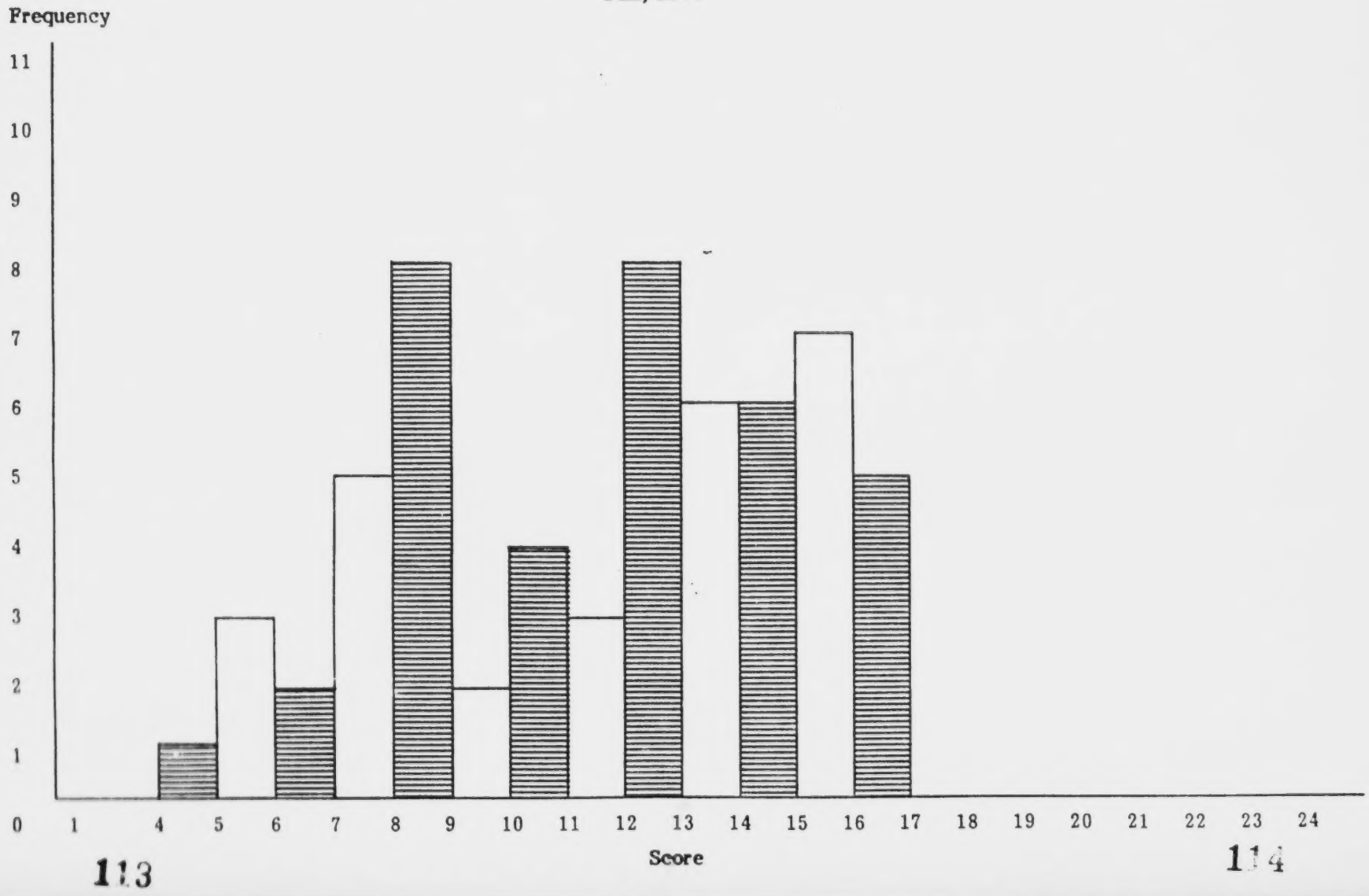


Figure 4

Frequency Distribution of Raw Scores for the
Subject Preference Questionnaire - Part II
Fall, 1984

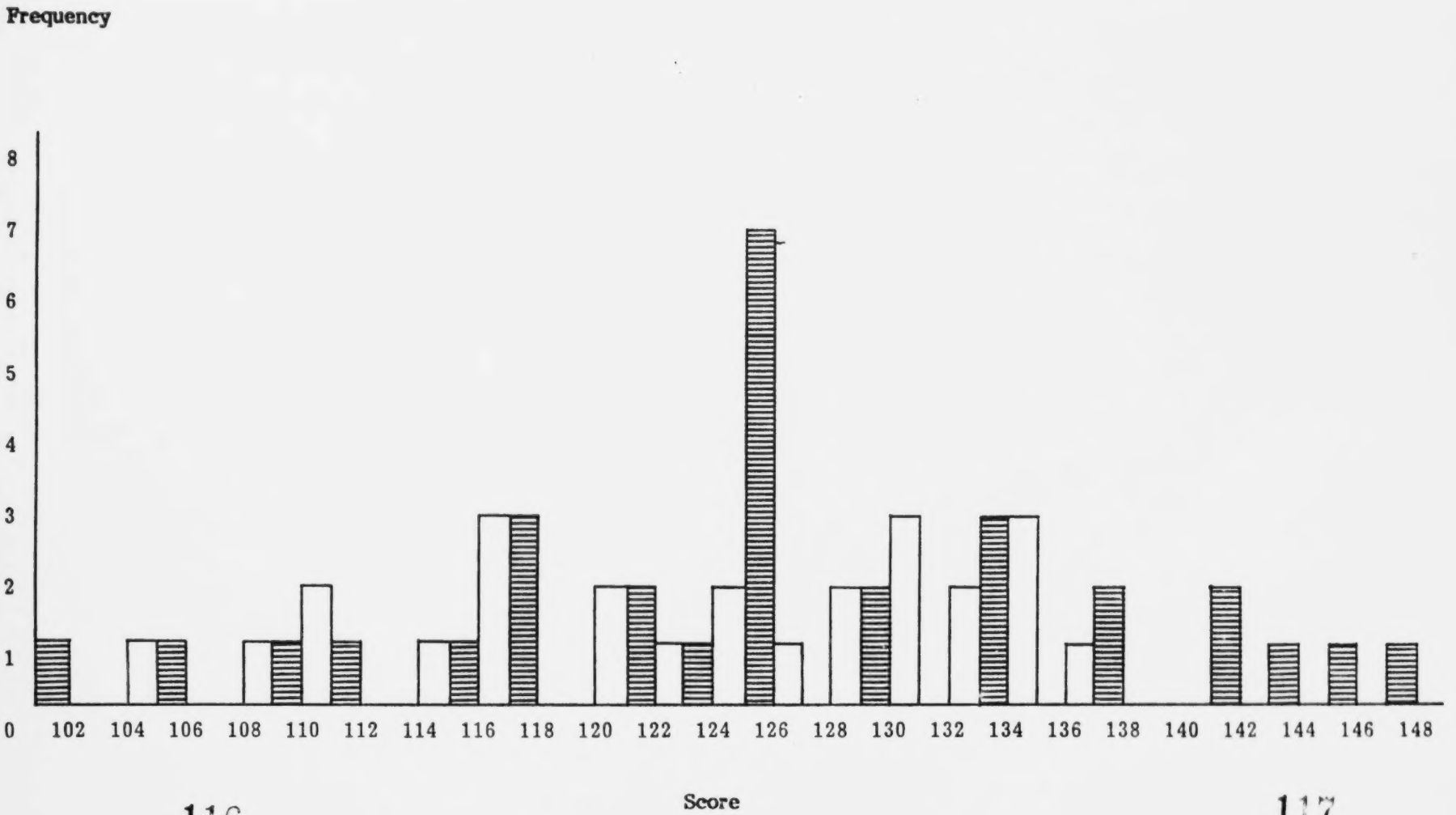


The Scientific Attitude Inventory (SAI) was developed by Moore and Sutman to assess student attitudes relative to certain aspects of science. The test consists of sixty statements followed by four choices ranging from "agree strongly" to "disagree strongly." The attitudes assessed are based on the objectives of science teaching as indicated in the NSSE fifty-ninth Yearbook. These attitudes consist of both emotional and intellectual approaches to science. An example of an emotional attitude is: "I would enjoy studying science and using this knowledge in some scientific field." An example of an intellectual attitude is: "Scientific laws cannot be changed." There are five items to assess each attitude. Complete acceptance of a positive attitude and complete rejection of a negative attitude rated a score of 15. Complete rejection of a positive attitude and complete acceptance of a negative attitude are given scores of zero. The maximum possible score is 180 and the minimum score is 0.

The SAI was field tested using three groups of tenth-grade biology students. The mean score for this group was 119. The mean score for the 1984, fall sample was 124.4. Figure 5 shows the distribution of scores for the fall, 1984 semester.

Figure 5

Frequency Distribution of Raw Scores for the Scientific Attitude Inventory (SAI)



Cognitive Instruments

The two tests used to assess cognitive level of achievement were the Biological Science Achievement Test (BSCS) and Nelson Biology Test. The BSCS test is a 50 item multiple choice test covering both biology content and process skills. The test was used as a pretest and posttest to measure changes in students' understanding of biology content and process skills.

The Nelson Biology Test is a 65 item multiple choice test used as both a pretest and a posttest to measure changes in students' understanding of biology content. Table 4 summarizes the pretest-posttest means for the fall, 1984 sample for the BSCS and Nelson Biology Tests.

Table 4

Mean Pre-Post Test Scores for BSCS and Nelson Biology Test

	BSCS		Nelson	
	Pre	Post	Pre	Post
Mean	26.4	29.9	40.8	48.1
N = 47				

Piagetian Instruments

Five tests were used to assess the Piagetian level of the students. These tests were Burney's Piagetian Objective Formal Instrument, the Metric Puzzle, the Apartment Puzzle, the Mealworm Puzzle and the Island Puzzle. The Metric, Apartment, Mealworm and Island Puzzles were used both as pretest and posttest measures of Piagetian level. Table 5 summarizes the Piagetian level of the fall, 1984 sample.

Table 5

Piagetian Level of B10 Students - Fall 1984

	Pre	Post
Non-formal Operational	51%	38%
Formal Operational	49%	62%

Analysis of Data

This section discusses the research questions formulated, the statistical procedures used to analyze the data and the results of these analyses.

(1) Is there a correlation between student achievement in the course and the Study Habits Inventory score?

A Spearman Rank Correlation Coefficient was used. Student achievement was correlated with the total test score for the Study Habits Inventory. A value of $r_S = -.15$ was obtained. This result indicates that there is no particular connection between students' achievement in the course and a students' grade on the Study Habit Inventory.

(2) Is there a correlation between student achievement in the course and the students' ratings of the previous high school biology course as measured by the Science Classroom Orientation Resolutionnaire?

A Spearman Rank Correlation Coefficient was used. Student achievement was correlated with the SCOR test score. A value of $r_S = .18$ was obtained. This result indicates that there is no particular connection between students' achievement and the students' perceptions of their previous high school biology course.

(3) Is there a correlation between Piagetian level and student achievement?

A point-biserial correlation coefficient was calculated. The students'

Piagetian level, as measured by the various puzzles, were correlated with the students' achievement in the course. A value of $r_{pb} = .13$ was obtained. This result indicates that there is no particular connection between the students' achievement in the course and Piagetian level.

(4) Is there a correlation between the Subject Preference Questionnaire and students' achievement in the course?

A Spearman Rank Correlation Coefficient was calculated to determine the correlation between the students' total score on the Subject Preference Questionnaire (S.P.Q.) and students' achievement in the course. A value of $r_s = .07$ was obtained. This result indicates that there is no particular connection between students' achievement in the course and students' preference for biology as measured by S.P.Q.

(5) Has the students' understanding of biology content increased as a result of the course work?

Two instruments were used to measure the gain in students' knowledge. These were the BSCS and the Nelson Biology Test. Both tests were given as pretests and posttests. A t-test, related sample, was used to analyze the data. Table 6 summarizes the results obtained.

Table 6

Biology Content Pretest-Posttest Results, B10 - Fall, 1984

Test	Mean Pretest	Mean Posttest	df	t
Nelson	40.8	48.1	47	5.28*
BSCS	26.4	29.9	53	5.54*

* $p < .05$

These results indicate that the observed differences between the means is

a significant one. Students' understanding of biology content increased as a result of the coursework.

(6) Has the students' understanding of process skills increased as a result of completing B10?

The BSCS test questions were analyzed by several instructors and those items that measured process skills were selected. A total of 18 items was identified. A t-test, related samples, was used to analyze the data. Table 7 summarizes the results.

Table 7

Process Skills Pretest-Postest Results, B10 - Fall 1984

Test	Mean Pretest	Mean Posttest	df	t
BSCS	26.6	30.3	44	2.6*

* $p < .05$

These results indicate that the observed differences between the means is a significant one. Students' understanding of process skills increased as a result of the coursework.

(7) Is there a significant difference in scores on the Subject Preference Questionnaire as a result of students' completing B10?

A t-test, related sample, was used to analyze the data. Table 8 summarizes the results.

Table 8

Subject Preference Questionnaire Results, B10 - Fall 1984

Test	Mean Pretest	Mean Posttest	df	t
Subject Preference Questionnaire	24.3	27.4	45	5.73*

* $p < .05$

This result indicates that students' perceptions of science as a preferred subject and science as being important to the general welfare of man increased significantly as a result of B10.

(8) Is there a correlation between scores on BSCS and Piagetian level?

A point-biserial correlation coefficient was calculated. The students' Piagetian level, as measured by the various puzzles, were correlated with the students' posttest scores on the BSCS exam. A value of $r_{pb} = -.01$ was obtained. This result indicates that there is no particular connection between the students' Piagetian level and posttest scores on the BSCS exam.

(9) Is there a correlation between scores on the Study Habits Inventory and the students' Piagetian level?

A point-biserial correlation coefficient was calculated. The students' Piagetian level as measured by the various puzzles was correlated with the students' total score on the Study Habits Inventory. A value of $r_{pb} = .33$ was obtained. This result indicates that there is no particular connection between these two variables.

(10) What are the demographic characteristics of the students who were unsuccessful in the course?

Table 9

Demographic Characteristics of Unsuccessful Students
B10 - Fall, 1984

ID	Ethnic	Sex	Age	MSSP	GPA	Major	H.S.	H.S. Biology
1	W	F	19	38	---	Pre-Nurs.	Oakville	Yes
13	B	F	18	3	---	Biology	No.County Tech.	—
15	W	F	21	---	---	Sec. Educ.	So.County Tech.	Yes
16	W	F	20	54	2.00	Biology	Pkway N.	Yes
41	B	M	18	21	2.00	Biology	N.Chris-. ian Bros. College	Yes
43	W	M	20	82	2.059	Biology	Fort Zumwalt	Yes
48	W	M	19	42	1.684	Biology	St.Mary	—
58	W	M	18	28	---	Biology	McCluer	Yes
62	W	F	24	---	3.00	Biology	Pkway N.	Yes
69	W	M	18	62	---	Bus.Adm.	Lindbergh	Yes
73	W	F	20	35	---	Biology	Roosevelt	Yes
74	W	F	18	46	---	Undeclared	Lindbergh	—
76	W	M	26	38	1.00	Biology	Berkeley	Yes

$\overline{X}$ Age = 20
% F = 54%
% N.W. = 15%
% Public = 85%
% Biology Majors = 69%

Summary

Three results were obtained that indicated a significant difference between pretest and posttest scores. The two instruments used to measure process skills and knowledge of biology content at the beginning and end of the B10 course, the Nelson Biology test and BSCS, indicated significant gains in both areas.

The test used to measure students' preference for biology as compared to other subjects, the Subject Preference Questionnaire, indicated a significant gain in students' preference for biology after completing the B10 course.

END NOTES

[1]Burney, Gilbert McCollum. "The Construction and Validation of an Objective Formal Reasoning Instrument," (Unpublished Ph.D. dissertation, University of Northern Colorado, 1974).

[2]Elizabeth F. Karplus and Robert Karplus, "Intellectual Development Beyond Elementary School," School Science and Math, LXX, no. 5 (1970) 398-406.

[3]Robert Karplus and Rita W. Peterson, "Intellectual Development Beyond Elementary School II: Ratio, A Survey, "School Science and Math," LXX, no. 9 (1970), 813-820.

[4]Robert Karplus, Anton E. Lawson et al., Science Teaching and the Development of Reasoning, a workshop developed at the University of California (Berkeley: Lawrence Hall of Science, 1977), pp. 6-2 - 6-12.

[5]Ibid.

APPENDIX A

Demographic Material for Accepting Sample
B10 - Fall, 1984

Day

Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Anderson, K.	1	White	F	65	(19)	38	Pre-Nursing	Oakville	Yes	Exc.
Aufsmith, M.	2	White	F	57	(27)		Non-Degree	Lafayette	Yes	C
Barwick, S.	3	White	M	64	(20)	54	Biology	Francis Howell	C	
Becker, P.	4	White	M	65	(19)	69	Biology	Vianney		B
Beckerman, S.	5	White	M	66	(18)	72	Biology	Pattonville	Yes	A
Beel, B.	6	White	M	66	(18)		Biology	St.Thomas Aquinas	Yes	B
Bollinger, E.	7	White	M	64	(20)	38	Psychology	Foreign H.S.		B
Brunson, L.	9	White	F	61	(23)	54	Undeclared	McCluer North	Yes	B
Brusatti, R.	10	White	M	66	(18)	46	Chemistry	Bishop Du Bourg		B
Carpenter, C.	11	White	F	61	(23)		Psychology	Washington	Yes	B
Chadduck, L.	12		F	65	(19)	58	Biology	Hazelwood West	Yes	C
Cooper, T.	13	Black	F	66	(18)	3	Biology	N. County Tech.		Exc.
Davis, L.	15	White	F	63	(21)		Sec. Ed.	S. County Tech.	Yes	Y
Diller, D.	16	White	F	64	(20)	54	Biology	Parkway North	Yes	D
Dyn, D.	17	White	F	65	(19)	82	Undeclared	Rosati Kain	Yes	B

Demographic Material for Accepting Sample
B10 - Fall, 1984

Day
Page 2

Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
English, K.	18	White	F	63	(21)	50	Elem. Educ.	Parkway Central		C
Eveld, D.	19	White	M	63	(21)	35	Undeclared	St. Thomas Aquinas	Yes	C
Faur, J.	20	White	F	66	(18)	88	Pre-Optometry	Fort Zumwalt		B
Finch, S.	21	White	M	59	(25)	72	Biology	Southwest	Yes	B
Fritts, F.	22	White	F	66	(18)	93	Biology	McCluer		B
Gerber, S.	24	White	F	62	(22)		Elem. Educ.	Bishop Du Bourg	Yes	C
Gibbs, J.	25	White	M	65	(19)	86	Undeclared	Parkway South		C
Gorzel, K.	26	White	F	65	(19)	46	Biology	McCluer North	Yes	C
Gruebbeling, K.	27	White	M	65	(19)	98	Undeclared	Hazelwood West	Yes	B
Hagood, B.	28	White	F	65	(19)	62	Pre-Med	Riverview Gardens	Yes	C
Hallemann, L.	29	White	F	64	(20)		Biology	GED Equivalency	Yes	A
Havlicek, M.	30	White	F	59	(25)		Biology	S. County Tech.		C
Hillemeyer, P.	31	White	M	63	(21)	93	Biology	Horton Watkins	Yes	A
Humphrey, C.	32	White	F	62	(22)	65	Biology	University City	Yes	A
Khan, M.	33	Asian	F	68	(16)	21	Pre-Med	West Virginia	Yes	B

Demographic Material for Accepting Sample
B10 - Fall, 1984

Day
Page 3

Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
King, D.	34	White	F	66	(18)	79	Biology	Hazelwood Central		C
Kulik, D.	35	White	F	60	(24)		Pre-Med	Maryland H.S.	Yes	A
Langhorst, A.	36	White	F	63	(21)	54	Biology	Ursuline Academy		B
Lavoi, W.	37	White	M	59	(25)		Biology	Minnesota H.S.		A
Leonard, J.	38	White	M	65	(19)	94	Biology	Vianney	Yes	A
Love, N.	39	Black	F	64	(20)	28	Biology	McCluer North		C
Manning, S.	40	White	M	66	(18)		Undeclared	McCluer	Yes	C
Marion, C.	41	Black	M	66	(18)	21	Biology	Christian Bros. College	Yes	F
Miller, P.	42	Black	F	64	(20)	18	Biology	Beaumont	Yes	C
Monday, M.	43	White	M	64	(20)	82	Biology	Fort Zumwalt	Yes	D
O'Brien, P.	46	White	M	66	(18)	46	Biology	St. Thomas Aquinas	Yes	B
O'Donnell, A.	47	White	F	64	(20)	72	Biology	Pattonville	Yes	B
Ortinau, T.	48	White	M	65	(19)	42	Biology	St. Mary	Drop	
Peters, K.	49	Black	F	63	(21)	46	Biology	Hazelwood Central	Yes	B
Poertner, E.	50	White	F	66	(18)	38	Biology	Pattonville	Yes	B

Demographic Material for Accepting Sample
B10 - Fall, 1984

Day
Page 4

Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Porter, L.	51	Black	F	64	(20)	14	Biology	Beaumont	Yes	B
Potts, C.	52	White	M	65	(19)	92	Anthropology	Hazelwood East	Yes	A
Preis, M.	53	White	F	61	(23)	54	Biology	Nerinx Hall		A
Rask, R.	54	White	M	53	(31)		Undeclared	Bishop Du Bourg	Yes	C
Roth, L.	55	White	F	65	(19)	79	Biology	Parkway North	Yes	B
Sanick, D.	56	White	F	66	(18)	58	Pre-Med	McCluer	Yes	B
Schulte, D.	58	White	M	66	(18)	28	Biology	McCluer	Yes	Drop
Schultz, D.	59	White	F	64	(20)	54	Pre-Med	St. Thomas Aquinas	Yes	B
Sczepanski, S.	60	White	F	66	(18)	99	Biology	John F. Kennedy	Yes	A
Siegmund, M.	61	White	F	65	(19)	94	Pre-Optometry	Notre Dame	Yes	A
Silverberg, L.	62	White	F	60	(24)		Biology	Parkway North	Yes	Drop
St. John, T.	63	White	M	65	(19)	79	Biology	Fox	Yes	B
Stanza, R.	64	White	M	58	(26)	92	Economics	St. Louis Country Day	Yes	B
Thomas, J.	66	Black	M	50	34		Pre-Med	Bishop Du Bourg	Yes	B
Titchen, J.	67	White	M	52	32		Biology	University City	Yes	A

Demographic Material for Accepting Sample
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Day
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Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Toennies, B.	68	White	F	65	(19)	69	Mathematics	Ritenour		B
Turner, S.	69	White	M	66	(18)	62	Business Admin.	Lindbergh	Yes	Y
Villacis, S.	70	White	F	66	(18)	82	Biology	Kirkwood	Yes	C
Walsch, P.	71	White	F	66	(18)	69	History	St. Charles	Yes	C
Weigle, M.	72	White	M	66	(18)	82	Biology	Hazelwood East	Yes	A
Zimmerly, M.	73	White	F	64	(20)	35	Biology	Roosevelt	Yes	D
Cloyd, C.	74	White	F	66	(18)	46	Undeclared	Lindbergh		Y
Farley, C.	75	White	F	66	(18)	88	Pre-Optometry	Fort Zumwalt	Yes	B
Lehmkuhl, T.	76	White	M	58	(26)	38	Biology	Berkeley	Yes	Y

APPENDIX B

Test Results

B 10 - Fall, 1984
Page Six

Evening

ID Code	Burney		Metric (Ratio)		Apt.		Mealworm		Island		BSCS		Nelson		Study Habit Inventory		Subject Pref.		SCOR	SAI	SRT	CI
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	A B C D		A	B				
101	23	F										37	51	56								
102	23	F	5		4		5		F		38	40	57	54								
103			5		2		3		C		26	26		46			11	9	15	127	28	
104	15	T	5		1		2		F		24	27	29	42	-3		12	9	5	135	30	15
105			3		1		4		F		34		44		21		63	17	109.5		23	18
106	17	F	4		4		4		C		28	40	42	24	62		14	15	12	136	14	27
107			4		4		3		F		28		23		31		12	12	22	136	20	11
109	14	T	3		1		4		C		26	31	41	50	-9		14	11	11	116.5	11	10
110	21	F	4		2		4		C		33		40		-29		14	13	18	136	15	12
111	22	F	4				4		F		30	34		48	43		15	14	14	141	29	11
112	17	F	1		5		3		C		31						13	15	9	142	24	
113	15	T	2		1		3		F		22	29	31	48	75							12
114	14	T	4		2		4		C		23		35	39	75				drop			5
115	18	F	4		4		3		F		21		33		54		15	7	20	123	23	19

Test Results

B 10 - Fall, 1984

ID Code	Piagetian Measures										Achievement Measures				Affective Measures						
	Burney		Metric (Ratio)		Apt.		Mealworm		Island		BSCS		Nelson		Study Habit Inventory	Subject Pref.		SCOR	SAI	SRT	CI
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	A B C D	A	B				
1	11	T	4		2		4		F		13		34		3	14	10	16	115	17	11
2	15	T	4	4	5	5	4	5	C	F	22	23	31	50	49	11	14	15	104	13	6
3	15	T	5		2		2		C		26		49	15	-82	16	16	22	---	25	39
4	17	F	5	4	5	1	5	3	C	F	28	30 -	41	53	46	13	15	16	128.5	16	15
5	18	F	5	5	3	1	1	5	C		29	36	51	51	-20	15	8	18	143	8	8
6	16	T	5	5	2	5	4	3	C	F	33	38	46	57	-42	11	8	6	110	14	12
7	13	T	4	4	2	3	3	3	F	F	31	35	46	52	63	13	5	10	141	17	13
9	16	T	5		5		4		C		29		42		37	12	10	15	134.5	24	10
10	14	T	4	4	4	2	3	3	C	F	21	25	29	45	21	10	8	12	105	15	9
11	15	T	5	1	4	3	3	5	C	C	32	30	40	49	74	16	15	8	125	27	10
12	11	T	1	1	4	1	4	5	C	C	23	25	32	44	40	14	12	13	145	19	9
13	5	C	2		1		4		C		15		7		37	13	10	12	119	19	8
15																14	6	7	143	20	
16	17	F	3		1		5		F		26		38	38	80	15	14	16	136	28	8
17	16	T	4	4	2	3	4	5	C	F	17	32	22	43	23	6	12	14	110	19	12
18			3		3		2		F		21		31								29
19	11	T	5		2		4		F		32		45	44	-2	13	7	13	114	17	11

Test Results

B 10 - Fall, 1984
Page Two

ID Code	Piagetian Measures: Burney		Metric (Ratio) Pre	Metric (Ratio) Post	Apt. Pre	Apt. Post	Mealworm Pre	Mealworm Post	Island Pre	Island Post	Achievement Measures: BSCS Pre	BSCS Post	Nelson Pre	Nelson Post	Affective Measures: Study Habit Inventory A B C D	Subject Pref. A	Subject Pref. B	SCOR	SAI	SRT	CI
20																12	10	5	142	21	
21	17	F	4	3	5	5	5	5	F	F	25		35	40	98	16	15	15	140	19	15
22	22	F	5	5	5	5	4	5	C	F	31	35	57	60	42	14	16	19	130	18	16
24	16	T	2	4	2	1	3	3	C	C	13	19	18	32	5	13	16	17	134	14	7
25			5	5	5	5	3	3	C	C	19	13	36	22	-21						3
26	17	F	1				4		C		28		45		43	15	11	16	132	28	18
27	21	F	5	5	5	5	3	3	F	F	30	30	40	50	30	12	5	20	120	22	8
28	15	T	5	3	5	1	4	3	C	C	28	25	35		64	12	7	13	125	23	10
29	19	F	2	2	1	1	4	3	C	F	26	30	51	48	-9	13	9	9	121	9	10
30			4	4	4	2	3	5	C	C	26	31	52	51	-37						27
31	20	F	5	4	5	5	5	5	C	F	30	34	50	79		11	16	13	147	27	11
32	19	F	4	5	5	5	5	5	C	F	24	30	40	90	76	10	8	21	137	23	22
33	16	T		1		1		2		C		20		44	104	12	8	16	124.5	16	
34	19	F	5	5	2	1	3	3	C	F	21	19	44	46	31	13	12	20	125	17	7
35	15	T	2	4	5	5	3	5	F	F	28	32	47	53	124	9	11		116	25	10

Test Results

B 10 - Fall, 1984
Page Three

ID Code	Piagetian Measures										Achievement Measures				Affective Measures						
	Burney		Metric (Ratio)		Apt.		Mealworm		Island		BSCS		Nelson		Study Habit Inventory	Subject Pref.		SCOR	SAI	SRT	CI
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	A B C D	A	B				
36	12	T	1	1	2	2	3	3	F	C	28	29	48	55	-3	10	13	19	126	22	15
37	21	F	4	4	5	4	4	3	C		33	34	58	55	36	16	14	5	117	18	13
38	18	F	4	4	2	5	4	3	F	F	23	34	42	54	80	16	13	19	134	5	11
39	17	F	5	4	4	2	3	3	F	C	18	26	41	39	50	10	14	10	128	25	11
40												34		61	40	15	15	21	143.5	17	
41												22		26		14	9	16	103	21	
42	13	T	5	3	1	1	4	3	C	F	23	27	31	39	62	11	10	7	133	21	9
43	15	T	5		2		3		C		28		48		35	15	16	20	109	14	23
46	17	F	1	5	4	3	3	3	C	C	35	32	56	55	-52	12	15	21	130	27	7
47	12	T	4	4	4	5	4	4	F	F	30	34	43	52	-35	16	124	6	124	29	9
48			5		3		4		C		23		30		-31	16	14	8	132.5	22	8
49	14	T	4		3		3		C		25	26	39	43	-16	10	8	11	129	31	8
50	18	F	4	5	4	1	4	4	F	C	25	31	32	50	57	13	8	16	116	19	13
51	17	F	4	4	2	1	4	5	F	C	19	23	20	37	-9	15	7	14	122	23	18

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Page Four

ID Code	Burney		Metric (Ratio)		Apt.		Mealworm		Island		BSCS		Nelson		Study Habit Inventory A B C D	Subject Pref. A	B	SCOR	SAI	SRT	CI
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post							
52	21	F	5	5	5	5	4	4	C	F	36	42	52	60	-5	15	12	20	130	13	18
53	20	F	5		5		4		C		23		39	55	18	12	11	13	137	18	15
54	15	T	5	5	5	5	3	5	C	C	30	26	36	42	-13	15	13	12	111	23	2
55	14	T	5	5	1	5	5	5	C	F	25	30	38	51	80	16	15	19	120.5	15	27
56	19	F	5	5	3	5	5	5	C	F	24	29	36	42	59	14	11	12	125	26	20
58			1		1		1		C		16		24		22	12	12	7	108	17	13
59	13	T	1	2	2	2	3	3	F	F	26	27	39	50	131	15	15	13	141	16	17
60	21	F	5	5	5	3	4	3	C	F	22	37	49	60	49	12	9	18	128	23	22
61	12	T	4	5	5	5	4	5	C	F	22	39	35	58	35	9	5	15	123	8	12
62	12	T	4		3		4		C		20		27		-4	13	14	11	101	13	4
63	17	F	5	5	4	5	4	3	F	F	21	30		55	37	15	11	14	119	11	9
64																16	15	24	120	34	
66	14	T	4	1	2	2	4	3	C	C	32	39	51	50	110	14	13	20	124	23	13
67	15	T	5		5	5	4	3	C	F	32	31	45	52	-54	14	7	12	133	29	17
68	14	T	5	5	5	5	3	3	C	C	26	19	27	45	690	8	12	9	108	27	12

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Page Five

ID Code	Piagetian Measures: Burney		Metric (Ratio) Pre	Metric (Ratio) Post	Apt. Pre	Apt. Post	Mealworm Pre	Mealworm Post	Island Pre	Island Post	Achievement Measures: BSCS Pre	BSCS Post	Nelson Pre	Nelson Post	Affective Measures: Study Habit Inventory A B C D	Subject Pref. A	Subject Pref. B	SCOR	SAI	SRT	CI
69																10	10	13	123	22	
70	19	F	4	4	5	4	4	3	F	F	27	26		53	64	14	8	21	117	14	22
71	15	T	5	5	3	2	4	3	C	C	35	36	52	46	11	10	12	24	117	14	17
72	21	F	5	5	5	5	3	4	F	F	29	35	44	61	143	13	13	19	116	24	10
73	18	F	4	1	2	1	3	4	F	C	24	24	17	42	64	15	7	16	120	17	1
74			4		1		3		F		33		58								6
75	20	F	4	4	5	5	3	4	C	F	33	34	48	56	76	12	4	19	132	12	18
76	29	F	5		5		4		F		18		29		68	14	15	19	125.5	21	10

APPENDIX E

EVALUATION REPORT

INTRODUCTORY BIOLOGY 10

EXPERIMENTAL DATA

Fall, 1986

Demographic Material for Accepting Sample
B10 - Fall, 1986

Day										
Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Anderson, M.	1	White	M	68	18	52	Biology	GED Equivalency		
Baker, M.	2	Black	F	68	18	54	Pre-Med	Clayton	Yes	
Bartley, S.	3	White	M	65	21	00	Undecided	St. Charles West	No	
Deekman, L.	4	White	F	68	18	92	Sec. Ed.	Rosati Kain	Yes	
Berglund, B.	5	White	F	66	20	99	Undecided	Dixon H.S.		
Bigby, K.	6	White	F	65	20	72	Undecided	Lafayette H.S., Clayton Rd.	Yes	
Bowers, A.	7	White	F	67	18	88	Undecided	Metro H.S.		
Bratton, R.	8	White	M	67	19	50	Biology	Hazelwood West H.S.	Yes	
Brooks, K.	9	White	M	66	20	21	Biology	Southern H.S., Ellington	Yes	
Brotherton, M.	10	White	F	65	20	76	Biology	Hillsboro H.S.	Yes	
Cameron, J.	11	White	M	51	34	00	Psychology	Foreign H.S.	Yes	
Cooper, M.	12	White	F	65	20	92	Chem.	Hazelwood Central H.S.	Yes	
Crocker, K.	13	White	F	66	20	92	Undecided	McCluer North H.S.	Yes	
Douglas, T.	14	White	M	68	18	96	Pre-Med	Kirkwood H.S.	Yes	
Gaffney, S.	15	White	F	57	29	54	Undecided	Webster Groves Sr. H.S.	Yes	

Demographic Material for Accepting Sample
B10 - Fall, 1986

Day										
Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Gallup, T.	16	White	M	60	25	00	Undecided	Horton Watkins H.S.		
Gartner, J.	17	White	F	49	37	94	Undecided	Jennings Sr. H.S.	Yes	
Gary, R.	18	Black	F	59	27	04	Biology	Soldan		
Grant, R.	19	Black	F	67	19	42	Biology	Hazelwood Central Sr. H.S.	Yes	
Greenblatt, S.	20	White	F	62	23	93	Biology	Pattonville R-3 H.S.	Yes	
Hawks, K.	21	White	F	67	19	76	French	Fort Zumwalt H.S.	Yes	
Holder, R.	22	White	M	48	38	00	Undecided	Brookfield Sr. H.S.	Yes	
Horvath, M.	23	White	F	68	18	54	Undecided	Hazelwood Central H.S.	Yes	
Hosty, C.	24	White	M	66	19	92	Biology	McCluer North H.S.	Yes	
James, M.	25	White	M	69	26	54	Biology	University City H.S.	Yes	
Johnson, L.	26	NA	F				Anthropology	Metro High	Yes	
Kasten, D.	27	White	M	66	20	62	Undecided	University City H. S.	Yes	

Demographic Material for Accepting Sample
B10 - Fall, 1986

Day										
Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Kerby, T.	28	White	F	64	22	62	Undecided	Oakville Sr. H.S.		
Klingenberg, I.	29	White	F	61	25	00	Pre-Vet.	Pattonville R-3		
Kraatz, S.	30	White	M	67	18	69	Undecided	Bishop DuBourg		
Krewet, C.	31	NA	F	65	20	18	Pre-Vet.	Sikeston H.S.	Yes	
Lamm, G.	32	White	F				Pre-Pharm.	Riverview Gardens H.S.		
Linger, D.	33	White	M	58	26		Sec. Ed.	West Virginia H.S.	No	
Little, M.	34	Black	F	67	19		Pre-Pharm.	Cardinal Ritter Institute	Yes	
Lopiccolo, M.	35	White	M	56	30		Biology	Mercy H.S.		
Mathieu, B.	36	White	F	58	27		Psychology	Webster Groves Sr. H.S.		
Michaud, J.	37	White	M	36	50		Biology	McBride H.S.		
Miramadi, K.	38	White	M	68	28	54	Pre-Med	Kirkwood H.S.	Yes	
Nolan, K.	39	White	F	65	21	86	Pre-Opt.	Lafayette H.S.	Yes	
Obrien, T.	40	White	M	68	18		Undecided	Fox H.S.		
Panetti, C.	41	White	F	67	19		Undecided	Hazelwood East H.S.	Yes	
Parrish, R.	42	White	F	54	21		Biology	Foreign H.S.	Yes	

Demographic Material for Accepting Sample
B10 - Fall, 1986

Day										
Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Phillips, C.	43	White	F	66	20	76	Biology	Washington H.S.		
Phillips, M.	44	White	M	56	29		Biology	Illinois H.S.	Yes	
Pointer, A.	45	Black	F	65	20	42	Pre-Opt.	Horton Watkins H.S.	Yes	
Prinzivalli, J.	46	White	M	67	19	69	Biology	Parkway West Sr. H.S.	Yes	
Reber, D.	47	White	F	60	26	46	Sec. Ed.	Lafayette H.S.		
Redensek, A.	48	White	F	59	27	46	Biology	GED Equivalency	Yes	
Rensing, J.	49	White	M	67	19	82	Undecided	Hazelwood East H.S.	Yes	
Rooney, S.	50	White	M	67	19	35	Undecided	Pattonville H.S.	Yes	
Savala, C.	51	White	F	66	20	52	Undecided	Parkway West	Yes	
Schneiderman, J.	52	White	M	68	18	82	Biology	Parkway Central	Yes	
Schoemaker, A.	53	Hisp.	M	69	17	65	Pre-Med	Foreign H.S.		
Scott, M.	54	White	F	65	20	00	Biology	Washington H.S.	Yes	
Sekarski, T.	55	White	M	65	21	82	Biology	St. Mary H.S.-St. Louis	Yes	
Silberberg, T.	56	White	M	57	29	00	Biology	Parkway West		
Simmons, G.	57	Black	F	65	21	16	Pre-Pharm.	Sumner H.S.	Yes	

Demographic Material for Accepting Sample
B10 - Fall, 1986

Day

Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Smallwood, J.	58	NA	F	68	18	46	Undecided	Pattonville R-3	Yes	
Smith R.	59	White	M	66	20	00	Comp. Sci.	Academy of Math & Science	No	
Sokolik, M.	60	White	M	66	20	00	Bus.	Horton Watkins	Yes	
Sperry K.	61	White	F	55	31	00	Biology	Connecticut H.S.		
Stayton, L.	62	White	F	61	24	62	Undecided	Southwest H.S.	Yes	
Steimetz, R.	63	White	M	65	21	00	Comp. Sci.	Missouri Military Academy		
Stinson, B.	64	White	F	64	22	00	Pshcyology	Parkway South	Yes	
Stone, G.	65	White	M	62	24	93	Eng.	Webster Groves H.S.	Yes	
Tentschert, J.	66	White	M	63	23	93	Pre-Eng.	Lindbergh H.S.	No	
Thomas, K.	67	White	F	68	18	00	Biology	Warren County R-3 H.S.	Yes	
Varvel, T.	68	White	M	64	22	00	Econ.	GED Equivalency	Yes	
Vigano, P.	69	White	M	66	20	00	Biology	Cassville H.S.	Yes	
Wagner, D.	70	White	F	67	19	54	Business	Pattonville R-3	Yes	
Wheeler, P.	71	Black	M	67	19	42	Biology	Cardinal Ritter Institute	Yes	
Winkelmann, S.	72	White	F	67	19	76	Undecided	Cor Jesu Academy	Yes	

Demographic Material for Accepting Sample
B10 - Fall, 1986

Day										
Name	ID Code	Ethnic	Sex	Birthday		MSSP	Major	High School	H.S. Biology Course	Achievement
				Year Born	Age					
Witte, K.	73	White	M	55	30	00	Biology	St. Thomas Aquinas		
Wu, F.	74	NA	F				Undecided	North Dakota H.S.	Yes	
Zimmerman, P.	75	NA	M				Pre-Opt	Indiana H.S.	Yes	
Zimont, J.	76	White	M	63	23	79	Comp. Sci.	Lafayette H.S.		